SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1903.

GENERAL PHYSICS.

373. *Mouth Barometer.* **P. Grützner.** (Ann. d. Physik, 9. 1. pp. 238–242, Aug., 1902.)—The author's mouth barometer, first described in 1895, consists of a flattened-out glass bulb and a bent glass tube, and is partly filled with coloured paraffin oil. The bulb is placed under the tongue (normal temperature 36·7° C.), and the reading is taken with the aid of a small mirror. In the author's instrument, which weighs 17 g. and has a length of 170·74 mm. corresponds to 1 mm. of mercury; in others the ratio is 1 : 1. In reply to Naber's criticisms, the author gives a table of comparative measurements which show the instrument to be suitable for approximate work. H. B.

374. *Silk Suspensions.* **V. Crémieu.** (Comptes Rendus, 135. pp. 682–684, Oct. 27, 1902.)—The author considers separately the simple filament and the double filament. The latter is the natural fibre, and can support weights of 8 and even 10 grammes, while the former supports 4. Under traction both kinds show two stages of elongation, that in which the twists and other inequalities due to the origin of the fibre, disappear, and that of the true elastic stretching. After treatment to get rid of this first state, the simple filament shows *no* torsional rigidity, and the double filament acts simply as a bifilar. Regarding the double filament as a unifilar under torsion, the Coulomb coefficient is 16×10^8. J. W. P.

375. *Elastic Constants of Silk Fibres.* **F. Beaulard.** (Comptes Rendus, 135. pp. 623–626, Oct. 20, 1902.)—Experiments were made to determine the Young's modulus and the rigidity modulus. For the latter the value found is $1{\cdot}288 \times 10^{10}$. In the determination of the former, it is found that the lateral contraction diminishes rapidly and attains a constant value when the load exceeds a few grammes; and that there is always a residual elongation of at times as much as 1/40 of the length. Repetition on the same specimen finds these effects less marked, and a hysteresis effect is sought for by repeated cycles of loading. The mean value $2{\cdot}52 \times 10^{10}$ is given for the Young's modulus. J. W. P.

376. *Measurement of Young's Modulus.* **W. Cassie.** (Phil. Mag. 4. pp. 402–410, Sept., 1902. Paper read before the Physical Society, Nov. 22, 1901.)—The apparatus described gives an oscillation method of determining Young's modulus, and can also be used without change to obtain a statical measurement. A horizontal bar (called the *needle*) is symmetrically supported by two equal parallel wires, which form part of the wire whose Young's modulus is to be determined. The moment of inertia of the needle can be adjusted by moving heavy cylinders fixed at either end by set screws, while its centroid can be raised or lowered by a gravity bob. The needle carries knife-edges which rest on double hooks hanging from the parallel wires. The needle is adjusted to be horizontal with its centroid in the vertical line midway between the suspending wires, while the latter are under equal tensions; the centroid is also adjusted to be at the level of the knife-edges; want of accuracy in the latter adjustment can be allowed for if necessary. Three periods of oscillation are observed: (1) The bifilar, about a vertical axis through the centroid of the needle; (2) the pitching, about a horizontal axis at right angles to the needle; (3) the rolling, about a horizontal axis along the length of the needle. The mass of the needle is also found. Formulæ are established showing how Young's modulus for the wires is deduced from those observations. In the statical method a small weight is hung on the needle at a succession of measured distances from the centre, and the differences of extension of the wires read by a beam of light reflected on to a scale; Young's modulus can be calculated from the data so found, along with the constants of the arrangement. No experimental results are given. W. S.

377. *Application of the Statics and Kinetics of Monocyclic Systems to the Theory of Elasticity.* **H. Reissner.** (Ann. d. Physik, 9. 1. pp. 44–79, Aug., 1902.)—This is a mathematical paper in which the author employs the monocyclic systems of Hertz. He endeavours to represent the thermo-elastic properties of gases, liquids, and solids as the statical properties of monocyclic systems; deviation from perfect elasticity (*e.g.*, permanent set, viscosity, elastic after-effect, and especially the irreversibility of elastic changes of state) is regarded as due to necessary departures in the chosen dynamical model from perfectly cyclic behaviour. W. S.

378. *Liquid Drops. Tate's Law.* **P. A. Guye** and **F. L. Perrot.** (Comptes Rendus, 135. pp. 459–461, Sept. 15, and pp. 621–623, Oct. 20, 1902.)—After recalling the earlier and little-known work of Frankenheim and Hagen, the authors state that the weight of drops is greater for rapid formation than for slow formation, the orifice being the same in both cases. Beyond a certain period of formation the weight is constant. Thus for a tube 8·17 mm. diameter, the weight is independent of time of formation if the latter exceed 80 seconds. In ascertaining experimental laws on drop formation, this time of formation should, therefore, be always taken into account. Experiments show that Tate's law is only approximately satisfied, and criticism of Leduc and Sacerdote's verification is given. The formation of the drops is studied photographically, and reproductions are given showing the successive stages of the process of formation. The drops are considered in two classes—*static* and *dynamic* drops. In the first case, the drops are formed so slowly that their weight is independent of their time of formation. In the second case the formation is rapid. The liquids employed were water, benzene, and aniline, and the tubes had external diameters of less than 4 mm. The authors conclude that Tate's law is not valid; that the phenomenon of dropping is comparable to that of rupture of metallic threads under traction,

and that the influence of the rigidity of the liquid should be studied. [See also Abstract No. 1472 (1901).] J. W. P.

379. *Determination of Capillarity Constants by means of Adhesion Plates.* **W. Gallenkamp.** (Ann. d. Physik, 9. 2. pp. 475–494, Sept., 1902.)—The author employs two methods for measuring capillarity constants. In the first of these he measures the weight required in one balance pan to pull a horizontal plate suspended from the other pan away from the surface of the liquid. From the measurements obtained in this way with water, Poisson's formula gives the mean value, $a^2 = 14{\cdot}782$ at 19° C. This method assumes, however, that the angle made by a liquid with a solid in contact with it has the value zero. The second method, which makes no such assumption, is as follows: The surface of the liquid column raised from the surface of a liquid by means of a flat plate contains, at one part, an infinitely narrow vertical ring, and, if the plate be lowered from its highest position, this vertical ring becomes more and more depressed until it comes into contact with the edge of the plate. This position is arrived at by adjusting the plate so that a horizontal ray of light striking the edge of the plate and the liquid in contact with it is reflected back along itself. The formula given in Kirchhoff's "Mechanik" leads to the following expression for a^2: $0 = -p/\mu\pi r - ar + a^2(2\sqrt{2} + 5)/6$; where p is the weight of liquid of specific gravity μ raised by the adhesion plate of radius r. The following results were obtained for a^2 by this method at 19–20° C.: Water, 14·606; alcohols of 14 different concentrations were examined, pure alcohol giving the value 5·983; sulphuric acid, 6·426; 10 per cent. sodium hydroxide solution gave the value 10·091, and 12 per cent. potassium hydroxide solution, 10·002, but these numbers are only approximate owing to the rapidity with which the solutions absorb carbon dioxide from the air; various calcium chloride solutions were examined, the saturated solution ($\mu = 1{\cdot}460$) giving the value 9·886; olive oil, 6·866.

The agreement between the numbers obtained for water by the above two methods demonstrates the truth of the assumption made in the first method, namely, that the angle formed by the edge of a solid body in contact with a wetting liquid has the value zero. T. H. P.

380. *Surface-tension at the Boundary of Alcohol with Aqueous Salt-solutions. Formation of Cells, Sphærocrystals and Crystals.* **G. Quincke.** (Ann. d. Physik, 9. 1. pp. 1–43, Aug., 1902.)—The surface-tension between ether and water is at first 1·25 mg./mm., but in three hours decreases by 33 per cent. owing to the partial miscibility of the liquids. The surface-tension between alcohol and water is very small and soon vanishes as the liquids mix, but aqueous salt-solutions give values up to 0·3 mg./mm. This surface-tension leads to the formation of drops and bubbles which may take up water and swell or give up water to the alcohol and shrink or crystallise. [See also Abstract No. 2 (1903).] T. M. L.

381. *A Problem of Clebsch, on the Motion of a Solid in an Infinite Liquid, and De Brun's Problem.* **W. Stekloff.** (Comptes Rendus, 135. pp. 526–528, Oct. 6, 1902.)—De Brun's problem is as follows: "To determine the motion of a solid whose molecules are attracted to a fixed plane by a force proportional to the distance, when the body has one point fixed in the attracting plane." The Clebsch problem is as follows: "To determine the motion of

a solid in an infinite incompressible liquid under no forces, assuming the kinetic energy to be given by—

$$2T = a_1x_1^2 + a_2x_2^2 + a_3x_3^2 + b_1y_1^2 + b_2y_2^2 + b_3y_3^2,$$

where ab are constants satisfying the equation—

$$\frac{a_3 - a_2}{b_1} + \frac{a_1 - a_3}{b_2} + \frac{a_2 - a_1}{b_3} = 0 \qquad (1).\text{"}$$

The author asserts that the two problems are in effect the same. Clebsch's problem reduces to the integration of—

$$(2)\ \frac{dx_1}{dt} = x_2b_3y_3 - x_3b_2y_2\ .\ .\ .$$

$$(3)\ \frac{dy_1}{dt} = (a_3 - a_2)x_2x_3 + (b_3 - b_2)y_2y_3\ .\ .\ .$$

In these equations b_1y_1, b_2y_2, b_3y_3 denote the component rotations p, q, r round axes fixed in the body, and $x_1 = k\gamma_1$, $x_2 = k\gamma_2$, $x_3 = k\gamma_3$, where k is an arbitrary constant, and γ_1, γ_2, γ_3 are the cosines of the angles which these axes make with the axis of z fixed in space. For if we substitute these values for x, y, &c., in (2) and (3) we get—

$$(4)\ \frac{dy_1}{dt} = \gamma_2r - \gamma_3q, \text{ \&c.}$$

$$(5)\ A\frac{dp}{dt} = (B - C)\,qr + (a_3 - a_2)k^2\gamma_2\gamma_3, \text{ \&c.}$$

where A, B, C are respectively $\frac{1}{b_1}, \frac{1}{b_2}, \frac{1}{b_3}$. We may always make—

$$a_3 - a_2 = \lambda(B - C), \quad (a_1 - a_3) = \lambda(C - A), \quad (a_2 - a_1) = \lambda(A - B)$$

consistently with (1). So (3) become—

$$A\frac{dp}{dt} = (B - C)(qr + k^2\gamma_2\gamma_3)\ .\ .$$

which with (4) are the differential equations in de Brun s problem. We have then the following thorem. The rotation about the origin fixed in the solid in the problem of Clebsch is the same as the movement of the solid about the fixed point in the problem of de Brun.

After mentioning the researches of M. H. Weber and M. F. Kötter on the problem of Clebsch, the author remarks that his equations admit, besides the three Kirchhoff integrals, of a fourth integral—

$$A^2p^2 + B^2q^2 + C^2r^2 + \lambda k^2(BC\gamma_1^2 + CA\gamma_2^2 + AB\gamma_3^2) = \text{const.}$$

which is identical with the fourth integral of de Brun. All the equations used by the above-named writers can be applied without modification to de Brun's problems.

The author concludes by pointing out a particular solution of the problem of Clebsch. The equation of condition (1) may be replaced by—

$$a_1 = \mu + \rho b_2b_3, \quad a_2 = \mu + \rho b_3b_1, \quad a_3 = \mu + \rho b_1b_2,$$

μ and ρ being arbitrary constants. Then (2) and (3) are satisfied by $y_1 = \lambda_1 x_1$, $y_2 = \lambda_2 x_2$, $y_3 = \lambda_3 x_3$; $\lambda_1 = \frac{Q}{\sigma + \rho b_1}$, $\lambda_2 = \frac{Q}{\sigma + \rho b_2}$, $\lambda_3 = \frac{Q}{\sigma + \rho b_3}$; $Q^2 = (\sigma + \rho b_1)(\sigma + \rho b_2)(\sigma + \rho b_3)$, σ being an arbitrary constant. The problem is then reduced to the integration of $\frac{dx_1}{dt} = \frac{\sigma}{\lambda_1}(b_3 - b_2)x_2 x_3$, with two corresponding equations, the integrals of which are known. This corresponds with a problem given by Poinsot. S. H. B.

382. *Brachistochrones.* **H. de la Goupillière.** (Comptes Rendus, 135. pp. 614–618, Oct. 20, 1902.)—The work equation for a particle of unit mass moving in a plane may be written $v^2 - v_0^2 = 2(T - T_0)$, where v denotes velocity and T is an analytical function of the forces; the author has shown that the differential equation of the brachistochrone corresponding to this system of forces may always be put into the form—

$$\frac{d \log(T - T_0 + v_0^2/2)}{dx} \cdot dy - \frac{d \log(T - T_0 + v_0^2/2)}{dy} \cdot dx = 2d\psi,$$

where ψ is the angle of contingence. He now considers the properties of those curves when the left-hand side of the above equation is a perfect differential. W. S.

383. *Interpolation on a Given Minimum Condition.* **F. Weeder.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 434–445, Nov. 29, 1902.)—While observing the rate of the Leyden Observatory mean clock, the author was led to develope a method of interpolation which may be applied to many other investigations. A variable quantity, as, for example, the correction of a clock, being observed through an extensive range of periods separated by various intervals, how is the value at a given moment to be interpolated? The author first considers the case of a least common divisor existing for all the intervals of time, this divisor being taken as the unit of time. The increase of the variable quantity per unit of time is ascertained by means of the condition that the sum of the second powers of their first differences, as calculated for the whole range of investigation, shall be a minimum. A. G.

384. *Harmonic Tidal Constants of Australian and Chinese Ports.* **T. Wright.** (Roy. Soc., Proc. 71. pp. 91–96, Oct. 31, 1902.)—The Australian ports are Ballina and Newcastle (N.S.W.), Princess Royal Harbour (King George's Sound), Brisbane, and Sydney. The figures given for the first three were derived from the continuous diagrams of automatic gauges; those at the latter two concern times of high and low water. The observations extend over a period of one year. The tidal ranges are small. The constants were determined after G. H. Darwin's method. Of the other ports, Hong Kong, Swatow, and Whampoa are again provided with automatic gauges, while at Cooktown and Cairn's Harbour only the times and heights of high and low water are determined. H. B.

385. *General Causes of Seismic Instability in India.* **F. de Montessus de Ballore.** (Comptes Rendus, 135. pp. 598–600, Oct. 13, 1902.)—The seismic instability of East India, between Brahmapootra, Himalaya, and Cape Comorin, is confined to certain districts, Kabul, Kandahar, Jellahabad, Khojah, Cashmere and Nepaul, the Murri Hills, Sellakonda, &c., and can be connected

with geological dislocations and faults. The author briefly indicates the chief cases; particulars will be published by the Geological Survey of India.

H. B.

386. *Rainfall Variations over Long Periods.* **J. Hann.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 67–186, 1902.)—The author has studied the rainfall records of Padua for the years 1725 to 1900, of Klagenfurt 1813 to 1900, and also of Milan 1764 to 1900. There was a long sequence of wet years in 1844 to 1851 at these three stations. No such long periods of dry years are known, though dry years predominate on the whole, and the frequencies of relatively dry and wet years are the same for the three stations. Judged by the quantity of the rainfall, however, Klagenfurt has more wet than dry years. There is no indication of an eleven years' sunspot cycle, either as regards quantity nor frequency of rain; but the Brückner period of thirty-five years can distinctly be traced. These latter cycles begin with the same years at the three stations, but the maxima and minima are by no means coincident. There are further long sequences of dry—not of wet—summers; certain months may keep dry for many years (October, 1827 to 1840, at Klagenfurt), and sequences of two or three dry months in the same year are more frequent than of wet months.

H. B.

387. *The General Problem of Seismography.* **M. Contarini.** (Accad. Lincei, Atti, 11. pp. 380–386, May 4; 433–439, May 18; 472–479, May 31; 519–527, June 15; and pp. 132–139, Aug. 17, 1902.)—The author refers to his former memoirs on the spherical pendulum, by the consideration of which he was led to the very general problem dealt with in this note, namely, that of a series of rigid bodies each connected with the one next in succession at one or several points. He now proposes to establish the general dynamical equations applicable to such a system.

The rigid bodies being n in number, $C_1, C_2 \ldots C_n$, in each one is taken an origin, and through that origin a system of rectangular axes of x, y, z. The origin chosen in C_r being P_{ro}, another point, P_{r1}, is taken in C_r, whose co-ordinates referred to the system of axes through P_{ro} are a_r, b_r, c_r, and P_{r1} is the point, or one of the points, at which C_r is connected with C_{r+1}, and is chosen for the origin in C_{r+1}.

If P_{ri} be any generic point in C_r, we have with these definitions $P_{r1} = P_{\overline{r+1}\,0}$, $x_{ro} = y_{ro} = z_{ro} = 0$, $x_{r1} = a_r$, $y_{r1} = b_r$, $z_{r1} = C_r$; and if x_{r2}, y_{r2}, z_{r2} relate to the centre of gravity of C_r,

$$x_{r2} = \Sigma_i m_{ri}\, x_{ri} / \Sigma_i m_{ri}, \text{ \&c.}$$

He then supposes a system of axes fixed in space, and the co-ordinates referred to them, ξ, η, ζ, and in particular ξ_{ri}, &c., are the co-ordinates referred to these fixed axes of a generic point in C_r. The most general motion of this system of connected bodies consists of a series of translations, ξ_r, η_r, ζ_r, for C_r, and so on, and a series of rotations (supposed small so that their squares may be neglected). The rotation of C_r is about a resultant axis fixed in it, through its origin P_{ro}, having components π_r, χ_r, ρ_r about the axes through P_{ro}, which are initially, *i.e.*, in case of no rotation, parallel to the fixed axes of ξ, η, ζ. Then the displacement of a generic point in C_r parallel to ξ due to this rotation is $\chi_r z_{ri} - \rho_r y_{ri}$, which he denotes by $(\pi\chi_i)_r$. It follows that—

$$\xi_{\overline{s+1}\,0} = \xi_{so} + a_s + (\pi a)_s,$$

and if ξ, η, ζ be the displacements of the first body, which are arbitrary—

$$\xi_{ri} = \xi + \Sigma_1^{r-1} a_s + x_{ri} + \Sigma_1^{r-1} (\pi a)_s + (\pi x_i)_r.$$

Having thus explained the geometry of his system, the author proceeds to obtain an expression for the virtual work. The equations most necessary for reference in the subsequent notes are the following—

$$(7)\ A\partial\xi + B\partial\eta + C\partial\zeta + \sum_{r=1}^{r=n} (H_r\partial\pi_r + K_r\partial\chi_r + L_r\partial\rho_r) = 0,$$

in which A, &c., H, &c., are set out, and (8), given below. The distinction is pointed out between the cases according as each point is connected with its next successor in one or in more than one point. If in one point only, the system has $3n + 3$ degrees of freedom, corresponding to $3n + 3$ equations of the form $A = B = C = H_r = K_r = L_r = 0$.

He proceeds then to the case in which the first body has one of its points fixed in the earth, so as to be affected by seismic disturbance. Through its centre is a system of axes, X, Y, Z, which, when there is no seismic disturbance, coincide with the fixed axes of ξ, η, ζ. The disturbance is then defined by the three translation displacements, ξ, η, ζ, and three rotations, α, β, γ, by which the two systems of axes are connected when they do not coincide. If λ_r, μ_r, ν_r denote the small rotations of C_r about its own X, Y, Z axes, then we have equation (F)—

$$(F)\qquad \pi_r = \alpha + \lambda_r.$$

The equation of virtual work becomes in this case—

$$(8)\qquad \sum_{r=1}^{r=n} (H_r\partial\lambda_r + K_r\partial\mu_r + L_r\delta\nu_r) = 0,$$

in which H_r, K_r, L_r are given.

In the second note the n rigid bodies of the general investigation are reduced to two, of which one is connected with the earth. The object in view is to deduce from the general formulæ consequences applicable to the theory of seismographic instruments. Equation (8) of the former paper here becomes—

$$\sum_{r=1}^{r=2} (H_r\partial\lambda_r + K_r\partial\mu_r + L_r\partial\nu_r) = 0 \qquad (9)$$

and the values of H_r, &c., are set out.

He now supposes that at the point P_{r1} of C_{r1}, *i.e.*, the point in which it is connected with the succeeding body, there are applied very small forces having components, Ξ_{r1}, H_{r1}, Z_{r1}, and at the centre of gravity of C_{r1} finite forces Ξ_{r2}, H_{r2}, Z_{r2}, and round the origin P_{ro} two couples of very small moment, that is two equal and opposite forces, X_{r3}, &c., applied at the points $\pm x_{r3}$, $\pm y_{r3}$, $\pm z_{r3}$. It is assumed also (2) that the accelerations ξ'', η'', ζ'' are of the same order of magnitude as the rotations, that is, very small. (3) That of the axes fixed in C_r, one passes through the centre of gravity of C_r, and that they are parallel to the principal axes of inertia, so that $\Sigma m_{ri}x_{ri}y_{ri} = 0$, &c. Also M_{rx} denotes $\Sigma m_{ri}(y_{ri}^2 + z_{ri}^2)$, &c. A seismographic instrument in its most general form consists of two spherical pendulums, a system of 6 degrees of freedom. They are suspended in such way that the z axes of either pass through the point of connection with the next—for instance, the z axis through P_{ro}, the origin in C_r, passes through P_{r1}, so that $a_r = b_r = 0$, and also through the centre of gravity of C_r, so that $x_{r2}=y_{r2}=0$. The forces applied at the centre of gravity are the weights of the pendulum, so that z being taken vertical, $\Xi_{r2}=H_{r2}=0$, $Z_{r2}=M_r g$. H_1, K_1, L_1 for the first body, and H_2, K_2, L_2 for the second are set out. The couples may be supposed to act at the points $0, \pm y_3, 0$, and are $\Xi_{r3}=\pm\tau_r$, $H_{r3}=Z_{r3}=0$. The effective equations of motion are found as follows for length l_2 :—

$$\begin{aligned}\xi''M_2+\beta''M_2(c_1+l_2)+\beta gM_2+\Phi_1&=0\\ -\eta''M_2+\alpha''M_2(c_1+l_2)+\alpha gM_2+\Psi_1&=0\end{aligned}\qquad(10)$$

$$\begin{aligned}\xi''M_2+\beta''\left(M_2c_1+\frac{M_2^{(y)}}{l_2}\right)+\beta gM_2+\Phi_2&=0\\ -\eta''M_2+\alpha''\left(M_2c_1+\frac{M_2^{(x)}}{l_2}\right)+\alpha gM_2+\Psi_2&=0\\ \gamma''M_2^{(z)}+X_2&=0.\end{aligned}\qquad(10')$$

Here Φ, Ψ, and X are terms arising from resistances. He concludes that in the ordinary instruments used in seismography the following conditions should be observed, namely—(1) the thread of suspension should be long enough, as compared with its diameter, to avoid the effects of curvature; (2) the pendulum weight should be practically a rigid body; (3) there should be a system of recording indices for registering the movement of the lower extremity of the thread. The forces acting on C_2 are three—(1) resistances due to the section and curvature of the thread very small compared with the weight, (2) the weight, (3) the torsion of the thread. He then gives, by reference to a former memoir, a method for determining the constants in the equations employed. With these modifications the instrument moves in accordance with (10), (10′), and these can be integrated if Φ, Ψ, X are known. The rotations about the horizontal axes are given by—

$$c_1\lambda_1=-Y_1,\quad c_1\mu_1=X_1,\quad c_2\lambda_2=-(Y_2-Y_1),\quad c_2\mu_2=X_2X_1.$$

The forces Ξ_{ri}, H_{ri} are then found, on the hypothesis that they vanish when the instrument is at rest—

$$\Xi_{ri}=-(p_rX_r+p_r'X_r'),\quad H_{ri}=-(q_rY_r+q_r'Y_r'),$$

and the constants p, q can be determined; and finally, if the instrument move when the earth is undisturbed, the equations of motion reduce to $\Phi_1=\Phi_2=0$, $\Psi_1=\Psi_2=0$. By means of such an instrument four out of the six motions due to seismic disturbance are determined. To determine the remaining two, involving vortex movements and overthrows, it is necessary to resort to an instrument analogous to Vicentius's microseismograph.

In the third note the author supposes the series of mutually connected rigid bodies to be reduced to one, and that connected with the earth. The equation (8) of the preceding notes is now, since the suffix r is no longer required—

$$H\partial\lambda+K\partial\mu+L\partial\nu=0,$$

and—

$$\begin{aligned}H=&\ \Sigma i(\eta_i-\eta)(Z_i-m_i\zeta_i''),\\ &-\Sigma i(\zeta_i-\zeta)(H_i-m_i\eta_i''),\end{aligned}$$

in which $\xi_i-\xi=x_i+\chi z_i-\rho y_i$, and $\eta_i-\eta$, $\zeta_i-\zeta$, have corresponding meanings. These equations are formed on the hypothesis that the rotations λ, μ, ν are very small, and that the axes fixed in the body coincide with the fixed axes in case of no rotation and no translation. In the case of the single body now considered, the only forces acting are the weight of the instrument and the resistances, which are very small compared with the weight, and can be expressed by a couple round the resultant axis of rotation, and by further reduction are equivalent to systems of equal and opposite forces at the points P_1, P_3 in the suspended body. Before entering on the general treatment of these equations, the author considers various classes of seismographic instruments. If the body be suspended at one point only it has three degrees of freedom, and the equations of motion are $H = K = L = 0$. If it can rotate only about a line fixed in itself, and that line can rotate round a line fixed in the earth and in the same plane with the first (called cardanic suspension), it has two degrees of freedom, and the equations of motion are two differential equations, of which the first members are linear functions of H, K, L. If the body can only oscillate round one line fixed in the earth, it has one degree of freedom, and in the single equation of motion has the first member a linear function of H, K, L. Instruments of the first kind, having three degrees of freedom, are those of Brassart, Agamennone, Vicentini, discussed by the author in a former work (Rendiconte, vol. x., 1° sem., serie 5ª, fasc. 5°, 6°). In this case the translation force (gravity) is $Z = Mg$; the resistance couples are two, one about a horizontal, the other about a vertical axis, the point P_1 being the centre of gravity (on the axis of z), and P_3 taken on the axis of x. The effective equations of motion are here—

$$\begin{aligned} &\xi'' m_y + \beta'' + \beta g m_y - \zeta'' \chi m_y + \Phi = 0 \\ (16)\qquad &-\eta'' m_x + \alpha'' + \alpha g m_x - \zeta'' \pi m_z + \Psi = 0 \\ &\gamma'' + (\xi'' \pi + \eta'' \chi) m_z + X = 0 \end{aligned}$$

where $m_x = \frac{Ml}{M^{(x)}}$, $m_y = \frac{Ml}{M^{(y)}}$, $m_z = \frac{Ml}{M^{(z)}}$.

The resistances, which do not depend explicitly on the seismic disturbance, are—

$$\Phi = \mu'' + \mu g m_y + \frac{Z_3 x_3 - \Xi_1 l}{M^{(y)}}$$

$$\Psi = \lambda'' + \lambda g m_x + \frac{H_1 l}{M^{(x)}}$$

$$X = \nu'' - \frac{H_3 x_3}{M^3}$$

An interesting case is that in which the point of suspension is the centre of gravity. For this the equations are given. Such an instrument is adapted to measure rotation only. To the second class of instruments belong approximately those consisting of an elastic cylinder or prism fixed in the earth at one end and connected at the other with an oscillating mass. The cases of practical importance are—(1) in which the bar is vertical in its undisturbed position. The rotation γ'' about the vertical axis is practically null, and the equations of motion are the two first of (16). (2) The case in which the bar is originally curved, and by the loading of its free end assumes a horizontal position. Taking its direction for axis of x, the equations of motion are $K = L = 0$. To the third class of instruments belong (1) horizontal pendulums, which he proposes to treat; (2) vertical pendulums of one component (Cecchi's seismograph), for which the equations are either $K = 0$ or $L = 0$; (3) seismographs for vertical component consisting of an elastic bar of rectangular section originally curved (the modified Vicentini). The horizontal pendulums (Milne, Rebeur, Paschwitz, Cancani), are defined as rigid bodies suspended by a quasi-vertical axis, not passing through the centre of gravity. A horizontal pendulum is in static equilibrium when the vertical plane through its axis contains the centre of gravity. If that centre be in the axis of x, the rotation must be in the plane of xz, or if ω be the resultant rotation, $\lambda = p\omega$, $\mu = o$, $\nu = r\omega$, and the equation of motion is $pH + rL = 0$.

In the fourth note the writer starts from the following assumption: "Every seismographic instrument is under the action of gravity, and of a system of passive resistances, which may be represented by a couple whose moment is very small compared with the weight of the oscillating body." To avoid the difficulty of integration owing to the indeterminate nature of the physical forces, he makes a second assumption, approximately verified by experiment, that "If the instrument moves while the earth is at rest, its component motions are isochronous oscillations subject to damping, according to the law of the logarithmic decrement."

It follows from the preceding notes that when the earth is at rest the equations of motion are $\Phi = 0$, $\Psi = 0$, &c., Φ, Ψ being the quantities used in equations 16. Any one of these Φ, Ψ equations is of the form $N = \epsilon'' + I\epsilon + J = 0$, where $\epsilon'' = \frac{d^2\epsilon}{dt^2}$, and ϵ is one of the rotations λ, μ, ν, ω, I is a known function of the weight, J a linear function of the unknown forces. In order to satisfy the assumption last made, ϵ must be of the form $\epsilon = e^{Ht}(P \sin Kt + Q \cos Kt)$, which is proved to be the general integral of—

$$\epsilon'' - 2H\epsilon' + (H^2 + K^2)\,\epsilon = 0.$$

The constants H, K depend upon the instrument, and can be determined. The object now is to find, as functions of the time, the six unknown seismic disturbances, viz., three translations, ξ, η, ζ, and three rotations, α, β, γ. This is to be deferred to another work. The equations are all of the form $F + N = 0$, where F is a linear function of the six unknowns. He concludes the present note with a proof of the following general theorem: "If the movement of the earth consists of a finite number of simultaneous rotations and translations, all very small and oscillatory, the apparent movement of the seismograph of whatever kind consists of a damped oscillation superposed on couples having periods usually equal to that of the seismic oscillation."

The equations being all of the form $F + N = 0$, where F is a linear function of the six unknowns, any one of the six unknowns, here denoted by θ, consists of r oscillations of semiperiod T_i with the maximum amplitude a_i, corresponding to the time t_i. Then—

$$\theta = \sum_{i=1}^{i=r} a_i \cos k_i(t - t_i), \text{ if } k_i = \frac{\pi}{T_i}.$$

The terms in F which depend on θ have the form $a\theta + b\theta''$, and can be included in $\sum_i^r (a - bk_i^2)a_i \cos k_i(t - t_i)$. Hence any one of the equations $F + N = 0$ takes the form—

$$\sum_1^s p_i \sin k_i t + \sum_1^s q_i \cos k_i t + \epsilon'' + A\epsilon' + B\epsilon = 0.$$

The above theorem is put finally in the following form: "On the foregoing hypotheses as to the nature of the seismic disturbance, the resulting motion consists of a damped oscillation superposed on s sinusoidal oscillations, whose period is in general equal to that of the seismic waves. The greatest amplitudes of the curves corresponding to those of the seismic waves and of the registered oscillations are connected by the equations—

$$m_i = b_i \sin k_i \tau_i, \quad n_i = b_i \cos k_i \tau_i."$$

In the fifth note the writer first points out a correction necessary in the differential equations 17–19 in Note III., in accordance with which they are given above in the corrected form. He then gives the equations which are applicable in practice to the different classes of systems described in Note III. This is done by reference to a diagram in which the different bodies composing the instrument are represented. It is assumed that "all the points of attachment of the instruments to be considered as subjected simultaneously to a mean seismic motion form with that part of the earth's crust of which the motion is to be measured a rigid system." He then finally sets out the equations applicable to the different kinds of instrument. For the vertical pendulum, consisting of the bodies shown as S_1, S_2 on the diagram, he gives for S_1—

$$\begin{aligned} &(X_1 = Y_1 = 0), \\ &\xi'' + \beta'' l_{x1} + \beta g + \mu_1 = 0, \\ -&\eta'' + \alpha'' l_{x1} + \alpha g + \lambda_1 = 0. \end{aligned}$$

For S_2 of the same instrument $X_2 = X$, $Y_2 = 0$.

$$\begin{cases} \xi'' + \beta'' l_{x2} + \beta g + \mu_2 = 0 \\ -\eta'' + \alpha'' l_{x2} + \alpha g + \lambda_2 = 0. \end{cases}$$

For the seismograph of horizontal mass directed towards the axis of y—S_3 on diagram—

$$X_3 = Z_3 = 0 \qquad l_{y3} = l'$$

$$\begin{cases} -\xi'' + \gamma'' l' - \beta g + \nu_3 = 0 \\ \zeta'' + \alpha'' l' + \lambda_3 \qquad = 0 \end{cases}$$

and for the other instruments in order. From the differential equations so given the problem of integration is reduced to that of finding a combination of instruments such that the corresponding equations shall be all independent and contain all the unknown variables. S. H. B.

388. *Chemical and Geological History of the Atmosphere. Part II. Composition and Extent of the Atmosphere in very Primitive Times.* **J. Stevenson.** (Phil. Mag. 4. pp. 435–451, Oct., 1902.)—Having previously (Phil. Mag., Sept. and Oct., 1900) shown that the primitive atmosphere probably contained no free oxygen, but considerable quantities of hydrogen and hydrocarbon gases, the author proceeds to discuss the reactions that may have gone on in the earth's crust, arriving at the conclusion that the primitive atmosphere was possibly several hundred times greater in extent than it is at present, and consisted essentially of carbon dioxide, in addition to hydrogen, hydrocarbon gases, and carbon monoxide. Particular reference is made to iron. Large masses of iron may have been reduced by the action of carbonaceous matter on molten oxides, and may have sunk to inaccessible depths; traces of metallic iron occur in some granites and basalts. The old rocks are, on the whole, basic, containing on an average 55 per cent. of bases and 45 of silica; the new rocks are acidic with 40 per cent. of bases and 60 of silica.

The decomposition was brought about by the carbon dioxide of the atmosphere, reacting with the molten or hot silicates, and the deficiency in bases is most marked as regards the iron oxides. The reduction of the iron would have required enormous masses of carbon, but there are bituminous shales in the Silurian and graphites in the Laurentian. Low organic life would, moreover, not have been impossible at the bottom of the assumed atmosphere, even though light could hardly have penetrated through it. H. B.

389. *Kites in the Upper Atmosphere.* **W. H. Dines.** (Soc. Arts, Journ. 50. pp. 858–859, Oct. 3, 1902. Report of a Committee of the British Association, consisting of W. N. Shaw, D. Archibald, C. V. Boys, A. Buchan, W. H. Dines, H. R. Mill, co-operating with Committee of the Royal Meteorological Society; read before Section A, Belfast.)—In the interests of the public safety and to obtain vertical temperature gradients near Ben Nevis, the apparatus has been erected on Crinan Island. The winding-in apparatus carries two reels and two strain-pulleys on the same shaft; as the kite is drawn in between the gusts of the wind, a four-cylinder steam engine of 6 h.p. has been preferred to a petroleum motor. The Dines kites (see Symon's Meteorological Magazine, April, 1902) differ somewhat from the Blue Hill pattern; two Cody kites are also used. The author is experimenting with the following instrument: A tube, closed at the top, contains air, sealed below by mercury or water; during the ascent, the air bubbles out, on descending, the mercury rises to a level corresponding to the minimum pressure. When a second tube filled with alcohol vapour is added, both temperature and pressure can be calculated. Sixty-eight ascents had been made, partly from a steam tug, the maximum height reached being 11,450 ft., when 21,350 ft. of wire were used. H. B.

390. *Bolographic Registration of Solar Radiation.* **S. P. Langley.** (Monthly Weather Rev. 30. pp. 258–260, May, 1902.)—The article is a short review of the first volume of the Annals of the Astrophysical Observatory of the Smithsonian Institution, and gives an outline of the method employed for the automatic registration of the heat radiation of the various regions of the solar spectrum. A large spectroscope with rock-salt prism is employed for producing the spectrum, and in the focal plane where the spectrum is formed there is exposed an extremely thin platinum strip. This strip forms part of a delicately adjusted electrical circuit, and any radiation falling on the strip alters its resistance, and in consequence causes the mirror of a delicate galvanometer included in the circuit to be deflected, the amount of movement depending on the intensity of radiation falling on the strip. After a long series of trials, it has been found possible to practically eliminate the "drift" of the galvanometer mirror, which, for the first few years, was a serious drawback, and this improvement has rendered possible the automatic recording of the movements of the mirror. A train of delicate clockwork is arranged to move the rock-salt prism at such a rate that the spectrum traverses uniformly across the thin platinum strip of the bolometer, while the light reflected from the moving galvanometer mirror is received on a photographic surface which is moved uniformly in a vertical direction, at right angles to the movements of the spot of light from the galvanometer. The curve thus produced, called a "bolograph," is such that the ordinates accurately correspond to the relative amounts of energy, and the abscissæ to the deviations in the prismatic spectrum. In this way the solar spectrum has been thoroughly explored between the A line, about wave-

length 0·8 μ, and a point far in the extreme infra-red at wave-length 5·3 μ. Over 700 absorption lines have been found, and their positions accurately mapped. Water-vapour is the cause of five great bands of progressively increasing magnitude, at the positions 0·92 μ, 1·1 μ, 1·4 μ, 1·8 μ, and 2·6 μ respectively. Great changes in the intensity of absorption of the water-vapour in our atmosphere have been detected in the course of these experiments, and as a complete bolographic record can now be obtained in about fifteen minutes, the method forms a most important means of studying the intricate problem of atmospheric absorption. C. P. B.

391. *Solar Observations during the first three Months of* 1902 *made at the Lyons Observatory.* **J. Guillaume.** (Comptes Rendus, 135. pp. 523–524, Oct. 6, 1902.)—On account of bad weather observations were only possible on forty-two days. Four groups of spots were observed with a mean area of 0·000639 (0·000189 for the last three months of 1901). Twenty-five days the sun was seen without spots. A notable group of spots crossed the sun's disc between the 3rd and 14th of March, the area when crossing the equator being 0·00065. On the 3rd of March there were three groups visible in latitudes + 24°, − 26° and + 24°; this has not occurred since September 7, 1901, when the three groups were in latitudes − 4, − 8 and + 8. Arguing from the relative positions of the spots, the author concludes that the 1901 and 1902 spots did not belong to the same cycle of activity, that the group of January 8, 1902, was one of the last appearances due to the last cycle, and that the minimum epoch had then passed. Tables are given showing the mean area and latitude of the spots and faculæ during the period. E. C. C. B.

392. *Fall of a Meteoric Stone near Crumlin, Sept.* 13, 1902. **L. Fletcher.** (Nature, 66. pp. 577–579, Oct. 9, 1902.)—A farm labourer heard a report, followed by a noise like escaping steam, at 10.30 a.m. on a cornfield near Crumlin, co. Antrim, 12 miles west of Belfast, and within a quarter of an hour, dug out a hot stone from a vertical hole in the ground, 1½ ft. in depth. Other people near by compared the noise to the rattle of a reaping machine; the detonation was heard at distances of over 10 miles. The meteorite had been stopped by a stone embedded in the ground. It is irregular in shape, about 7½ × 6½ × 3½ in., covered with a black or brown crust, and shows the usual "thumb-marks," iridescence in one spot, a nodule of proto-sulphide of iron, and specks of nickel iron; the weight is nearly 10 lbs. Other parts of the meteorite may have fallen into Lough Neagh, 3½ miles further west. There had been no fall of a meteorite in the British Isles during the last twenty-one years, and the specimen is the largest found in the British Isles for eighty-nine years. H. B.

393. *Theory of Shooting Stars. Stationary Radiant Points in Latitude* 45°. **O. Callandreau.** (Comptes Rendus, 135. pp. 557–559, Oct. 13, 1902.)—The author points out that the resemblance between meteors and comets is not so decided as was first thought from Schiaparelli's discovery that the velocity of the former is parabolic. Based on Kleiber's catalogue of the 918 radiant points determined by Denning, he made a table of the centres of radiation for each degree of longitude between latitude 40° and 50°, and noticed a distinct tendency on the part of the radiant points to condense in groups. It is impossible to attribute this to chance and to deny the existence of a persistent radiation within the above limits of latitude. As a mean latitude for the radial points 45° may be taken. It is easy to see that a number of orbits, with

a period of revolution differing but little from that of the earth, gives rise to a radiant point stationary in longitude if the directions of the perihelia of the orbits form a condensation. Considering the Laplace integrals of elliptical motion—

$$0 = f + \frac{k^2x}{r} - \gamma\frac{dy}{dt} + \beta\frac{dz}{dt},$$

$$0 = f' + \frac{k^2y}{r} + \gamma\frac{dx}{dt} - \alpha\frac{dz}{dt};$$

and putting—

$$\alpha = \gamma\frac{dz}{dt} - z\frac{dy}{dt}, \quad \beta = z\frac{dx}{dt} - x\frac{dz}{dt}, \quad \gamma = x\frac{dy}{dt} - y\frac{dx}{dt} = k\sqrt{p}\cos t.$$

For the point of collision between the meteors and the earth—

$$z = 0, \quad \alpha = y\,dz/dt, \quad \beta = -x\,dz/dt;$$

the above equations become—

$$0 = f + \frac{k^2x}{r}\left(1 - \frac{r}{k^2}\cdot\frac{dz^2}{dt^2}\right) - \gamma\frac{dy}{dt},$$

$$0 = f' + \frac{k^2y}{r}\left(1 - \frac{r}{k^2}\cdot\frac{dz^2}{dt^2}\right) + \gamma\frac{dx}{dt}.$$

Comparing these with the theoretical equations for determining the longitude L and latitude B of the radiant point of a stream—

$$-g\cos\mathrm{B}\cos\mathrm{L} = \frac{dx}{dt} + k\frac{y}{r}$$

$$-g\cos\mathrm{B}\sin\mathrm{L} = \frac{dy}{dt} - k\frac{x}{r}$$

$$-g\sin\mathrm{B} = \frac{dz}{dt}$$

it is clear that, on the hypothesis that the velocity equals that of the earth, and that the latitude B = 45°, and generally that $\gamma = k - \frac{r}{k}\frac{dz^2}{dt^2}$, the equations which determine the longitude of a radiant point do not differ from Laplace's integrals, and that $\tan \mathrm{L} = \frac{f}{f'}$, only depends on the longitude of the projection of the perihelion of the orbit upon the fixed plane. The idea of the condensation of the perihelia in a group of orbits is not inadmissible. It is necessary to compare the velocities in order to find out whether these, corresponding to stationary radiant points, are less than parabolic. E. C. C. B.

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394. *Antifriction Arrangements.* **J. J. Taudin Chabot.** (Phys. Zeitschr. 3. pp. 513–515, Aug. 15, 1902.)—The author discusses these in general, and describes a rolling arrangement with pendulum and graduated arc which may be used as a dynamometer for small forces. A. D.

395. *Meteorological Observations made at St. Maurice during April, May, June, and July,* 1902. **R. Gautier.** (Archives des Sciences, 10. pp. 442–449, Oct., 1902.)

LIGHT.

396. *Apparatus for Orthogonal-parallel Projection Photographs by Means of X-rays.* **H. Boas.** (Zeitschr. Instrumentenk., Beib. 16. pp. 153–156, Aug. 15, and 17. pp. 163–165, Sept. 1, 1902.)—After describing and discussing previous forms of apparatus for giving orthogonally projected pictures by means of X-rays, the author describes his own apparatus in which a U-tube carries on one limb the X-ray tube, on the other a fluorescent screen with a style in the middle, the X-rays being directed towards the style. The U-tube is balanced and can rotate about its middle limb, and there is a further motion, so that X-ray tube and style can move together in any direction in parallel planes, and can thus trace simultaneously the outline of the object of which a photograph is required. The apparatus can be adjusted to take photographs in any position. The second part of the paper deals with the exactness obtained and the effect of a wrong adjustment of the X-ray tube. G. E. A.

397. *A Lecture-Room Biprism.* **A. Winkelmann.** (Zeitschr. Instrumentenk. 22. pp. 275–279, Sept., 1902.)—Using a suggestion from Abbe, the author has made an apparatus which can produce interference bands visible to a distance of 8 m., and which consists of a biprism immersed in benzol. The path difference is calculated for rays passing through prism, liquid, and containing wall to the first and second bright bands, and the condition for uncoloured bands is obtained. In practice, however, complete achromatism is prevented by the different dispersions in the liquid and in glass. When the biprism has acute angles of 4° 30′ and is placed 18 cm. from an illuminated slit, and 800 cm. from a screen, the distances between the bands are, for the C, D, and F lines, 12·4, 11·9, and 12·2 mm. respectively, and, for a non-immersed biprism, 12·4, 11·0, and 8·9 mm. A diverging lens may be used to increase the distance between the bands. G. E. A.

398. *Shattuck Solar Attachment.* (Eng. and Mining Journ. 74. pp. 315–316, Sept. 6, 1902.)—The paper describes a combination of two mirrors, one movable with regard to the other by means of a screw, to fit in place of the cap on the objective of a theodolite telescope, and for use in making solar observations, *e.g.*, determining the meridian. The apparatus weighs about 3 oz., and may be carried in the pocket without fear of damage. G. E. A.

399. *Instrument for Aiming Guns Under Cover.* (Nature, 66. pp. 493–494, Sept. 18, 1902.)—A system of mirrors called a hyposcope is attached to the rifle, enabling the shooter to aim from a point 8 or 9 in. below the trigger-guard. The instrument was used at Bisley this year, when the average score at 200 yards range was 32·15 out of a possible 35 per man, the apparatus being new to nearly every man who shot. G. E. A.

400. *Testing of Optical Instruments.* **C. V. Drysdale.** (British Optical Journ. 1. pp. 250–254, June; 308–310, Aug., and pp. 11–16, Sept., 1902.)—The paper gives simple methods for testing most kinds of optical instruments, and, although chiefly for the use of opticians, forms a convenient compendium also for the general reader. The defects due to material, workmanship, and

design being first enumerated, the rest of the paper is then divided into five sections under the headings: General; Telescopes, Opera and Field Glasses; Photographic Lenses; Projection Apparatus; and Microscopes. Under the first heading are given methods for determining the equivalent focal length of an optical system of considerable axial length; the three different senses in which the term magnification is used are then distinguished, and methods are given for testing the transparency of the glass, plane surfaces, plane-parallelism, the curvature of surfaces, the centring of lens systems and their chromatic and spherical aberration. The following sections take up these points, among others, according as they apply to the particular class of instrument considered. G. E. A.

401. *Focal Lengths.* **J. Precht.** (Phys. Zeitschr. 3. pp. 515–517, Aug. 15, 1902.)—If the magnification, in a camera, be M diameters, the image (ground-glass screen) is at M focal lengths behind the imageward focus of the lens, and the object is at 1/M focal lengths beyond the objectward focus. If two negatives be made of the same mm. scale, and if these show the respective magnifications, M′ and M″, the difference in the camera extension in the two cases is (M′ — M″) focal lengths; and from this it is easy to find the focal length. The best values of M′ and M″ for this purpose are about 1½ and ¼ to ½ respectively. The errors are within 4·05 per cent. when $f = 27$ cm. and under 0·2 per cent. when $f = 15$ cm. A. D.

402. *Prisms and Plates for Showing Dichromatism.* **R. W. Wood.** (Phys. Rev. 15. pp. 121–122, Aug., 1902.)—The usual method of showing change of tint in the transmitted light with increasing thickness of the absorbing medium, is to superpose two or more strips of tinted glass or film. This method does not demonstrate clearly the cause of the change of colour, which is due to the fact that the coefficient of absorption is greater for one absorbed region than for some other. If the medium be given the form of an acute prism, and a source of light be viewed through it, the transmitted colours are separated, and the change in intensity of each with increasing thickness can be followed by moving the eye from the refracting edge towards the base. The author has made prisms of this nature in the following way: Canada balsam is boiled down until it will harden on cooling, and a quantity of brilliant green is dissolved in it. The dye must not be added until the balsam has cooled till it is almost thick. The amount should be such that a layer of the liquid 1·5 cm. thick appears red. Thin layers appear blue, and a prism of the mixture will show a blue-red dichromatism. But green-red dichromatism, which is much more striking, can be produced by adding naphthol yellow. A small hollow prism is warmed and filled with the mixture. As soon as the balsam is hard a small quantity of melted sealing-wax is poured on top of it, which increases the strength of the prism. A lamp-flame viewed through this prism is separated into a red and a green image, and as the eye moves towards the base the green image fades away, while the red one scarcely changes. If a broad flame be used, the overlapping portion of the two images will be seen yellow, secondary yellow due to mixture of red and green on the retina. By making the balsam solution of the dye much stronger and pressing it between plates of glass, slightly prismatic plates may be prepared which are red along one side, yellow in the middle, and green along the other side. In the case of one of the author's plates the colour of the transmitted light appears almost exactly that of the sodium flame, and yet a sodium flame is absolutely invisible through it. The dependence of the

colour on the original composition of the light is also well shown by these plates, some appearing red by lamplight and green by daylight, like Alexandrite crystals. The prisms should be about 4 cm. long, and 2 cm. thick at the base. A. E.

403. *Invisibility of Transparent Objects.* **R. W. Wood.** (Phys. Rev. 15. pp. 123–124, Aug., 1902.)—A transparent body disappears when immersed in a medium of the same refractive index and dispersion. This is usually illustrated by dipping a glass rod into Canada balsam, but the disappearance is not complete, for the dispersions of the glass and liquid are different. A better fluid is a solution of chloral hydrate in glycerine. The glycerine is to be heated and the crystals added until the refractive index has the required value. The hot liquid will dissolve 10 or 15 times its bulk of chloral, Rayleigh has pointed out that a perfectly transparent object would become absolutely invisible in uniform illumination. This last can be attained by placing the object within a hollow globe, the interior surface of which is painted with luminous paint. A quantity of Canada balsam is boiled down, and Balmain's paint in the form of dry powder is stirred into it. Two glass evaporating dishes of equal size are cleaned and warmed and coated on the outside with the hot mixture, which can be flowed over the entire surface by dexterous manipulation of a small Bunsen flame. A small hole can be cut in the coating, when hard, to obtain a view of the interior. If the inner surfaces be exposed to bright light, and then taken into a dark room, a glass stopper placed inside will be quite invisible. A. E.

404. *Alteration of Optical Properties of Glass by Elastic Deformation.* **F. Pockels.** (Ann. d. Physik, 9. 1. pp. 220–223, Aug., 1902.)—Among the glasses examined by the author for the influence of pressure on the velocity of light, there was one O 428, whose constant of elasticity was not known, and therefore had to be calculated from the chemical composition by empirical formulæ. The value obtained was $\nu = 0{\cdot}268$. Since then the value has been found by direct experiment to be $\nu = 0{\cdot}187$—a result which illustrates the fallibility of formulæ in such cases. On substituting the corrected value of ν, certain anomalies in the previous results disappear. In particular, the glass in question now forms no exception to the rule that the velocity of the extraordinary wave in glass is diminished by mechanical pressure. Of all the glasses examined, O 428 is now found to exhibit the smallest change of index, and the strongest double-refraction, for a given expansion. The author's and Pulfrich's observations show that the influence of thermal expansion on the light velocity is different from that of an equal amount of expansion produced mechanically. Hence in many cases it would be convenient to express the optical changes as functions of the principal pressures instead of the thermal expansions. A table of constants required for doing so is given. [See also Abstract No. 2029 (1902).] A. E.

405. *Construction of Luminous Rays on Curved Wave Surfaces.* **J. Boussinesq.** (Comptes Rendus, 135. pp. 559–563, Oct. 13, 1902.)—According to the theory of Huyghens and Fresnel, a luminous ray propagated in a homogeneous medium, and consisting of waves bounded laterally, can be formed as follows, namely, by describing about any point on it the envelope of all the wave surfaces passing through that point, and joining it with the point of contact of that envelope with the particular wave considered. The usual proof of that theory, says the author, is confined to the case in which each of the second time differential coefficients of the displacements, ξ, η, ζ, $d^2\xi/dt^2$, &c., is equated to a linear function of the second space derivatives of ξ, η, ζ, according to mean co-ordinates denoted by x, y, z. It is desirable to prove the theorem for the general case, especially as physicists are in the habit of applying it where the above conditions are not fulfilled.

The writer starts from Cauchy's formula (1) $\xi = \mathrm{L}e^{k(t-t_0)\sqrt{-1}}$, &c., with $t_0 = lx + my + nz$, in which L, M, N are the amplitudes, and in an indefinite wave are constants, but in a wave limited laterally are functions, varying very slowly, of x, y, z. Differentiating (1) we obtain these expressions—

$$-k\sqrt{-1}\left(l + \frac{\sqrt{-1}}{k}\frac{\partial}{\partial x}\right)\mathrm{L}$$

with corresponding expressions for m, M, y, and n, N, z—these he writes in the form $-k\sqrt{-1}(l+\partial l)\mathrm{L}$—&c., l, m, n being supposed to vary slowly. In the indefinite wave we should obtain by substitution in the equations of motion—

$$(3)\ \phi\mathrm{L} + \chi\mathrm{M} + \psi\mathrm{N} = 0, \quad \phi_1\mathrm{L} + \chi_1\mathrm{M} + \psi_1\mathrm{N} = 0, \quad \phi_2\mathrm{L} + \chi_2\mathrm{M} + \psi_2\mathrm{N} = 0$$

which involve the vanishing of the determinant of the coefficients ϕ, χ, ψ. On the other hand, for the laterally limited waves l, m, n, and consequently ϕ, χ, ψ, will be variable, and (3) become (4) $\phi\mathrm{L} + \chi\mathrm{M} + \psi\mathrm{N} + \mathrm{L}\partial\phi + \mathrm{M}\partial\chi + \mathrm{N}d\psi = 0$, &c. The same form obtains, he shows, for the *effective* differentials, *i.e.*, the real parts of the differentials, if for $\partial\phi$, &c., we substitute $d\phi$, &c., corresponding to variations dl, dm, dn, for which—

$$xdl + ydm + zdn = 0.$$

We have then—

$$(5)\ \phi d\mathrm{L} + \chi d\mathrm{M} + \psi d\mathrm{N} + d\phi\mathrm{L} + d\chi\mathrm{M} + d\psi\mathrm{N} = 0, \text{ \&c.}$$

Now since the determinant of ϕ, χ, ψ vanishes, we may introduce three factors λ', μ', ν', and write (6) $\phi\lambda' + \phi_1\mu' + \phi_2\nu' = 0$, &c. And now multiplying (4) and (5) respectively by λ', μ', ν', and adding, he obtains—

$$(\lambda'\partial\phi + \mu'\partial\phi_1 + \nu'\partial\phi_2)\mathrm{L} + (\lambda'\partial\chi + \mu'\partial\chi_1 + \nu'\partial\chi_2)\mathrm{M} + (\lambda'\partial\psi + \mu'\partial\psi_1 + \nu'\partial\psi_2)\mathrm{N} = 0$$

$$(\lambda'd\phi + \mu'd\phi_1 + \nu'd\phi_2)\mathrm{L} + \lambda'd\chi + \mu'd\chi_1 + \nu'd\psi_2)\mathrm{M} + (\lambda'd\psi + \mu'd\psi_1 + \nu'd\psi_2)\mathrm{N} = 0$$

whence further he finds—

$$(8)\ \mathrm{P}\frac{\partial \log \mathrm{I}}{\partial x} + \mathrm{Q}\frac{\partial \log \mathrm{I}}{\partial y} + \mathrm{R}\frac{\partial \log \mathrm{I},}{\partial z} = 0$$

$$\mathrm{P}dl + \mathrm{Q}dm + \mathrm{R}dn = 0$$

in which $\mathrm{P} = \lambda'\frac{d\phi}{dl} + \mu'\frac{d\phi_1}{dl} + \nu'\frac{d\phi_2}{dl} = 0$, and Q, R have corresponding values, and $\mathrm{I} = \mathrm{L}/\lambda = \mathrm{M}/\mu = \mathrm{N}/\nu$. The first of (8) shows that I is constant for each plane wave in the direction P, Q, R. The second of (8) shows that x, y, z, the co-ordinates of the point of contact of the wave with the envelope, are proportional to P, Q, R—*i.e.*, the radius vector drawn from the origin to the point of contact has the direction of wave motion. It traces the luminous ray. In order that there may be permanent plane waves with constant amplitude I in direction of the ray, whatever be the ratios between l, m, n it is sufficient that the equation in l, m, n has real roots. And the waves may be bounded laterally in any arbitrary way. S. H. B.

406. *Extension of Fermat's Principle of the Economy of Time to the Movement of Light relative to a Transparent Heterogeneous Body having a Rapid Motion of Translation.* **J. Boussinesq.** (Comptes Rendus, 135, pp. 465–470, Sept. 22, 1902.)—This paper should be read in connection with a note by the same author [see Abstract No. 206 (1903)]. The writer refers also to a former paper [C. R. vol. 129, p. 794] in which he proved that Fermat's principle applied to rays of light broken by reflection or refraction, but still composed of rectilinear portions. In the present paper he extends the principle to the case in which the rays undergo continuous flexure. He supposes a body bounded by the plane of *yz*, made up of plane layers parallel to that plane, and having a proper velocity whose components are V_x, V_y, V_z, such that their squares and products are negligible, and a series of plane waves incident from the region of negative x on the plane yz. The mean or undisplaced co-ordinates of any point in the body referred to axes attached to it are x, y, z. The displacements are ξ, η, ζ, and, if the body were homogeneous, would be wholly transversal, but in the heterogeneous body are shown to have a small longitudinal component. The absolute index of refraction of the body is N, a function of x, slowly variable. He takes from his note of July 28 [see Abstract No. 206 (1903)] the system of equations—

$$\frac{N^2}{\omega^2}\left(\frac{d^2\xi}{dt^2} - 2\left(V_x\frac{d}{dx} + V_y\frac{d}{dy} + V_z\frac{d}{dz}\right)\frac{d\xi}{dt}\right) = \Delta_2\xi - \frac{d\theta}{dx}, \text{ \&c.}$$

["In the July paper the factor is N^2/ω^2. In this paper it is N^2. But the dimensions seem to require N^2/ω^2."]

of which the right-hand member is the known expression for the elastic action, θ denoting the cubical dilatation. The results obtained are as follows: (1) If l, m, n are the components of wave velocity, δ the resultant of ξ, η, ζ, let $\phi' = \delta\sqrt{l - V_x}$. Then he finds—

$$(l - V_x)\frac{d\phi'^2}{dx} + (m - V_y)\frac{d\phi'^2}{dy} + (n - V_z)\frac{d\phi'^2}{dz} = 0.$$

In other words, if we follow the motion of a wave, ϕ'^2 is constant along a path having direction cosines proportional to $l - V_x$, $m - V_y$, $n - V_z$. These paths are the luminous rays. (2) If i be the angle between the direction of the ray and x. $N^2\sin^2 i = (m - V_y)^2 + (n - V_z)^2 =$ constant, which is Fermat's principle. (3) If λ, μ, ν be the direction cosines of the perpendicular to δ and the wave normal, $\lambda\xi + \mu\eta + \nu\zeta = 0$, and $\lambda\partial_r\xi + \mu\partial_r\eta + \nu\partial_r\zeta = 0$, in which $\partial_r\xi$, &c., are the increments of the projection of δ on the luminous ray. In other words, the transversal displacement δ on the same wave, following the same ray, turns continuously in the plane containing the wave normal. (4) The azimuth of polarisation is conserved. (5) It has been assumed that the time variation of δ is continuous. If that condition were not satisfied diffraction would take place, which is not discussed in this paper. S. H. B.

407. *Chemical Action of Light.* **G. Ciamician** and **P. Silber.** (Accad. Lincei, Atti, 11. pp. 145–151, Sept. 7, 1902.)—Results are given of a number of experiments made to determine which rays of the spectrum cause the accelerating action in the reactions previously studied by the authors (*loc. cit.*). The actions of two kinds of light are described: (1) a red light, obtained by absorption with an alcoholic solution of fluorescein and gentian-violet, and (2) a bluish-violet light, for which a 10 per cent. alcoholic solution of cobalt chloride was employed. Glass tubes containing the reacting substances were immersed in these solutions contained in glass cylinders exposed to the action of sunlight. In all the cases examined, the reactions are favoured by the more refrangible rays. The accelerating influence is hence a photochemical one, and is not due to the prolonged action of solar heat. [See also Abstract No. 2030 (1902).] T. H. P.

408. *Action of Light on Chlorine.* **J. W. Mellor.** (Chem. Soc., Journ. 81. and 82. pp. 1280–1292, Sept., 1902.)—From the experiments carried out by the author on this subject, the following conclusions are drawn: There is no experimental evidence to show that chlorine gas under the influence of light undergoes any change capable of appreciably affecting the chemical activity of that element towards hydrogen. Part of the energy absorbed by moist chlorine from sunlight is dissipated by heat, which causes the Budde effect—the expansion of chlorine under the influence of light rays of high refrangibility. Under the influence of light, chlorine sets up and maintains in a state of equilibrium a reversible reaction with water vapour, possibly that expressed by the equation: $2H_2O + 2Cl_2 \rightleftarrows 4HCl + O_2$. Dry chlorine does not exhibit the Budde effect. A layer of moist chlorine just thick enough to screen a bulb of mixed hydrogen and chlorine gases from chemical action is not sufficient to prevent chemical action if the chlorine is dried by means of purified phosphorus pentoxide. The actinic energy continuously absorbed from sunlight by moist chlorine is continuously dissipated in at least three ways: (1) partly in maintaining the above chemical reaction; (2) partly by conversion into heat during molecular impacts; (3) partly as external non-actinic radiations from the molecules moving in their free path between molecular collisions. T. H. P.

409. *Persistence of Vision in Colour-Blindness.* **F. Allen.** (Phys. Rev. 15. pp. 193–225, Oct., 1902.)—Between 0·400 μ and 0·730 μ, the period of persistence first descends from 0·0388 sec. to 0·0185 sec. (at 0·567 μ) and rises to 0·0240 according to a "persistence-curve" which is much the same for all normal eyes of about equal ages. Where there is colour-blindness we find elevations in this curve: (1) in the red-orange, (2) in the green, (3) in the red and in the green, (4) in the region red to green, (5) in the red and in the violet, (6) in the green and in the violet, or (7) throughout the spectrum. These elevations correspond to colour-blindness towards the respective parts of the spectrum. These facts fit the Young-Helmholtz much better than the Hering theory. In few cases is the colour-blindness confined to one sensation; case (7) above corresponds to total colour-blindness, of which a case is described. There appears to be always a white basis on which the colour is superposed. [See also Abstract No. 496 (1901).] A. D.

410. *Sensitiveness of the Eye to Colour.* **A. Pflüger.** (Ann. d. Physik, 9. 1. pp. 185–208, Aug., 1902.)—The absolute and the relative sensitiveness of the eye to colour is subject to extreme personal differences and to individual variations. It is the greatest between $\lambda = 495$ μμ and $\lambda = 525$ μμ, being about 60 times as great as for $\lambda = 413$ μμ, and 33,000 times as great as for $\lambda = 717$ μμ. After a holiday the sensitiveness may be found 59 to 110 times as great, but falls back to half that after two days. The "grey" light from copper oxide at 415° is a minimum green, and as the temperature rises, other minimum grades of colour come in until the whole spectrum is above the minimum at 525°. A. D.

411. *Binocular Vision.* **C. S. Sherrington.** (Roy. Soc., Proc. 71. pp. 71–76, Oct. 31, 1902.)—Talbot's law is not applicable to binocular vision as it is to monocular. Increase of luminosity of an intermitting image does not always necessitate increase of rate of frequency to extinguish its flicker. The Fechner paradox regarding binocular luminosity makes itself apparent under "flicker" as well as under "brightness" estimation. The physiological sum of two luminosities perceived through two conjugate retinal areas is intermediate between the individual values of the two component luminosities. Binocular colour mixture is not rendered easier or impeded when the components are applied by alternating right and left stimuli as compared with applying them by coincident right and left stimuli. A. D.

412. *Photographic Emulsion containing Ag or Ag_2Br.* **E. Baur** and **T. Portius.** (Phys. Zeitschr. 3. pp. 491–495, Aug. 1, 1902.)—The effect of exposing plates to light before exposure, and so rendering them more sensitive, or of over-ripening the gelatine, imitated by the introduction, into AgBr collodion emulsion, of solution of colloid silver or of Ag_2Br in collodion. The absorption of Br by Ag_2Br is very slow, so that when a plate is exposed the Br set free diffuses away before the latent image is destroyed by recombination. The Ag_2Br of the latent image is, in a gelatine film, slowly reduced by the gelatine to Ag_2. The idea of the experiments was to add to AgBr emulsion a quantity of Ag_2Br less than what exposure to light would produce, and less than what would cause fogging. If the Ag_2Br be to the AgBr as 1 : 1,000,000, the emulsion is not developable. Such an addition does not sensitise the plate; the diffused Ag_2Br does not act upon the granules of AgBr. No better success, except in one instance (which could not be reproduced), attended the preparation of plates by the wet-plate method, with Ag_2Br 1 to 500,000 in the bromised collodion; but the densities were increased by this addition. Colloid silver acts in the same way as Ag_2Br. A. D.

413. *Graphical Treatment of Interference.* **E. R. Drew.** (Phys. Rev. 15. pp. 226–232, Oct., 1902.)—As an aid to clearness, the interference of light in thin films is treated by a graphical method. The loci of points of maximum disturbance being hyperbolas of which the parts considered may be represented by straight lines, these are constructed by locating two points on a chosen hyperbola and drawing a straight line through them. Cases of parallel and wedge-shaped films of air and water between glass plates are treated, and the results of interference are reasoned out from the drawings. G. E. A.

414. *Diffraction into a Rare Medium at Angles Greater than the Critical Angle.* **E. Edser** and **E. Senior.** (Phil. Mag. 4. pp. 346–352, Sept., 1902.)—In a certain direction the wave theory as regards refraction from a dense to a rare medium has not been followed to its logical conclusion, and a somewhat paradoxical phenomenon has escaped observation. When a wave is incident on the interface between two media, each point of the interface becomes a source of disturbance giving rise to secondary spherical wavelets which may or may not reinforce one another, secondary wavelets being formed in all cases in each of the two media, even when the angle of incidence exceeds its critical value. That a superficial disturbance penetrates the second medium at least as far as $\frac{\lambda}{4}$ is shown by the persistence of the black spot formed by contact of a prism and lens after the coloured rings have dis-

appeared, for an angle of reflection greater than the critical angle. Reinforcement of the wavelets in the rare medium is produced by placing a grating in contact with the interface, and it is calculated that, in order to see the first diffraction spectrum of the wavelets by looking along the surface, the grating should have more than 2,000 lines to the inch. The above results are verified experimentally by means of a Nobert grating (8,000 lines to the inch), cemented to the hypotenuse face of a right-angled prism placed on a spectrometer table so that the beam from the collimator is received normally on one prism face. On looking along the surface of the grating, brilliant diffraction spectra are seen, and on rotating the prism so as to increase the angle of internal incidence on the grating, the central, undiffracted image disappears, but no change occurs in the general appearance of the diffraction spectra, which, however, disappear one by one as the prism is rotated. G. E. A.

415. *Variation of Double Refraction in Strained Glass with Wave-length.* **L. N. G. Filon.** (Cambridge Phil. Soc., Proc. 11. pp. 478–492, Aug., 1902.)—Experiments are carried out with a view to test Wertheim's conclusion that double refraction due to strain exhibits no dispersion. Polarised light, which can be taken from any part of the spectrum, is passed horizontally through glass beams bent over two knife-edges by means of levers actuated by weights. Starting with the equation : retardation = C × stress × thickness of glass, where C is a coefficient depending on the nature of the material and on λ, it is shown that the dark lines produced on a scale (by crossed Nichols at 45° to the vertical) are at distances proportional to λ/C, or, in the actual case, to λ/Cp, where p is another coefficient. Tables of values of $(Cp)^{-1}$ are given, and the results show that C increases from the red to the violet, the increase being more apparent from measurements taken from the upper half of the glass beam. The author therefore considers that Wertheim's law is not accurately true, and that the artificial double refraction due to strain does exhibit dispersion, the difference in the refractive indices being smaller in the red than in the violet by about 6 per cent. The results are confirmed by recent work done by Pockels. [See Abstract No. 2029 (1902).] G. E. A.

416. *Magneto-optic Phenomena in Absorption Bands.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 5. pp. 805–811, 1902.)—This is a mathematical discussion of some new appearances observed by Zeeman in photographs of the absorption bands of a sodium flame in a magnetic field, looking parallel to the lines of force. Plane-polarised light fell upon the flame, and then passed through a quarter-wave plate of mica, whose directions of polarisation were at ± 45° to its own, a system of quartz prisms, and, finally, a Nichol. The emergent light was analysed by a Rowland grating. Besides the vertical absorption bands, the photographs show a system of weak interference fringes on which, however, is projected a very intense interference phenomenon represented in the paper. The details are clearest when the vapour is rare. The striking feature is the difference of appearance between the two D lines. In D_1 the dark bars between the fringes all slope one way, in D_2 they form a zigzag. The author gives a theoretical explanation, illustrated by diagrams. He shows that the contrast just mentioned is due to the fact that the difference of velocity of the components of the doubly refracted wave is not the same for D_1 and D_2. This conclusion has also been borne out by direct observation. [See also Abstract No. 305 (1903).] A. E.

417. *Degree of Promptitude of Magnetic Birefringence.* **Q. Majorana.** (Accad. Lincei, Atti, 11. pp. 139–144, Aug. 17, 1902.)—A magnetic field is produced, capable of making an active solution birefringent, by means of a spark from a condenser, and the spark itself is used as the source of light. By a compensation method, which would not produce compensation if it were otherwise, but which does produce compensation, it is shown that the beginning of the birefringence is contemporaneous with the beginning of the luminosity of the spark. A. D.

418. *Bimagnetic Rotation of Plane of Polarisation.* **Q. Majorana.** (Accad. Lincei, Atti, 11. pp. 90–98, Aug. 3, 1902.)—Referring to previous papers [see Abstract Nos. 1844 (1902) and 218 (1903)], practical directions are given, including empirical preparation of various solutions found to be active when freshly prepared. The bimagnetic rotation observed is equivalent to an unequal absorption of the vibrations parallel and normal to the lines of force. For the same liquid in the same vessel in the same field the ratio of the tangents of the angles which the vibration makes with the lines of force on entering and emerging from the liquid is constant. The maximum rotation occurs when these angles are approximately 45°. To every positive bimagnetic rotation would correspond a negative magnetic birefringence, and *vice versâ*, if the unequal absorptions referred to above were the complete explanation of the phenomena; but this does not seem to be always the case. A. D.

419. *Universal Spectrum Apparatus.* **H. Lehmann.** (Zeitschr. Instrumentenk. 22. pp. 261–269, Sept., 1902.)—An apparatus designed for photographic or visual observation with one glass or quartz prism or transmission grating. It is provided with a telescope objective, as collimator lens, of 17 cm. focus, and an aplanat of 25 cm. focus as camera objective; or in their place two simple uncorrected quartz lenses for use with a half right and left quartz prism. The uncorrected quartz lenses have been shown by Hartmann to be preferable for use with quartz prisms on account of the flatter field they give [see Abstract No. 1013 (1900)]. An auxiliary tube is provided carrying a scale the image of which is reflected in the usual way from the last prism face. This scale tube carries a photographic aplanat as lens, not an achromat; this enables the whole scale to be photographed with sharp definition on the plate. E. C. C. B.

420. *Remarkable Spectrum from a Diffraction Grating.* **R. W. Wood.** (Phil. Mag. 4. pp. 396–402, Sept., 1902. Paper read before the Physical Society, June 20, 1902.)—A grating ruled by one of the Rowland dividing engines gives, at certain angles of incidence, perfectly sharp, monochromatic images of a glow-lamp filament in different parts of the first order spectra. On a spectrometer table the grating shows, at a certain angle of incidence, one of the D lines but not the other, the change in intensity being 10 to 1, a change of wave-length of 1/1000 being sufficient to cause this drop in intensity. The author found, when studying coloured images, that, when the plane of polarisation is parallel to the groove of a grating, the image colour is quite different from what it is when the plane is at right angles to the groove; and it was found that the anomalies of the above grating were exhibited only when the direction of vibration was at right angles to the ruling. The appearance of the spectrum under different conditions is described in detail. G. E. A.

421. *Spectrum Analysis.* **E. Haschek.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 232–243, 1902. From the Physikalisch-chemischen Institute of the University in Vienna.)—An account is given of observations on the change of position of various lines in the spectra of different substances. The effect of changes of vapour density on the position of the lines was determined. In order to overcome various sources of error and to have well-defined mixtures of substances to deal with, definite amalgams or alloys were employed. The amalgams were investigated in arc spectra. Alloys of the elements zinc, tin, aluminium, and mercury were used, and the relation between quantitative composition and wave-length of the lines was found to be the same for these four elements. It is regarded as highly probable that the same relation holds in the case of the lines of all the elements which suffer displacement. The spectra were obtained by help of a Rowland grating, and the known positions of the lines in the spectrum of iron were taken as points of reference, photographs of the spectra being obtained. Tables are given showing the change of position of certain of the lines when the composition of the alloys and amalgams is varied. The percentage composition and the wave-length of the lines are given in each case, and the figures show clearly the influence of the vapour density on the wave-length, and indicate that the displacement increases proportionally to the vapour density. When the change of the line with vapour density is accurately known indications as to the percentage composition of an alloy may be got from spectrum observations. The application of the method to astrophysics is suggested as quantitative estimates of the composition of the heavenly bodies might be obtained. [See also Abstract No. 2100 (1901).] J. J. S.

422. *Effect of Mercury Vapour on the Spectrum of Helium.* **J. N. Collie.** (Roy. Soc., Proc. 71. pp. 25–27, Oct. 17, 1902.)—In this note the author describes some observations on the spectrum of a mixture of helium and mercury vapour when illuminated by the discharge from an induction coil. A Plücker's tube containing pure helium shows the well-known eight bright lines of helium in the capillary portion, and in the negative glow some other fainter lines. The effect of mixing mercury vapour with the helium is to simplify the spectrum of the negative glow and at the same time to completely extinguish the three helium lines at $\lambda = 7065$, 4713 and 4472 ; the yellow line at $\lambda = 5876$ also becomes very feeble. The orange mercury line at $\lambda = 6151$ is very brilliant which, as a rule, in a vacuum tube containing only mercury vapour, does not appear. It was found that argon, krypton, hydrogen, and other gases do not, when mixed with mercury vapour, accentuate this line ; the effect of neon could not be determined owing to the close proximity of one of the neon lines. If the vacuum tube be made with a piece of tubing of about 4 mm. internal diameter set between two pieces of capillary tubing the following spectra can be seen : In the capillary portion the complete helium spectrum. At the negative glow the helium spectrum less the three lines noted above ; the D_3 line is very weak. In the central portion of wider bore only the green line of helium at 4922 is visible. The mercury spectrum is of course strongly visible in the three cases, and in the negative glow the orange line is the most brilliant. The three helium lines which are extinguished from the negative glow spectrum and the D_3 line belong to Runge and Paschen's helium spectrum, while the others visible in the negative glow belong to their par-helium spectrum. The author does not consider that this necessarily supports these authors' contention that helium is a mixture, on account of the fact that changes also are to be observed in the spectra of argon, neon, and krypton under the same treatment. Finally, the author suggests the use of such a mercury helium tube containing a trace of hydrogen for purposes of calibration in spectrometric measurements.

E. C. C. B.

423. *Absorption Spectra of Phloroglucinol and some of its Derivatives.* **W. N. Hartley, J. J. Dobbie** and **A. Lauder.** (Chem. Soc., Journ. 81. and 82. pp. 929–939, Aug., 1902.)—It is impossible from purely chemical reactions to prove whether phloroglucinol possesses an enolic or ketonic structure, as it behaves differently towards various substances. The absorption spectra of its aqueous solution are, however, identical with those of the trimethyl ether, which is undoubtedly enolic in structure; from this fact and also from the shape of the absorption curves the authors conclude that phloroglucinol has the enolic structure. The spectra of the mono- and di-hydroxy benzenes were compared and found to be very similar. The phloroglucinol was prepared from five different sources, no difference being noticed in the results.

E. C. C. B.

424. *Effect Intensity of the Carbon Spectrum in Presence of Hydrogen.* **A. M. Herbert.** (Phil. Mag. 4. pp. 202–207, Aug., 1902.)—Huggins noticed in 1864 that when carbon is subjected to the induction spark in the presence of hydrogen the strong line in the red is not seen. The experiments described in this paper were undertaken to test this, and it was found that, when sparks were passed through various mixtures of hydrogen and carbon monoxide or dioxide, the red carbon line was much more easily masked than the other lines, being almost invisible when a mixture containing 50 per cent. of hydrogen was used, while the bright line in the violet was quite visible with a mixture containing more than 90 per cent. of hydrogen. The author suggests that the red and violet lines belong to two different spectra. E. C. C. B.

425. *Photography of Infra-red Spectra of the Metals of the Alkaline Earths.* **H. Lehmann.** (Ann. d. Physik, 9. 1. pp. 246–247, Aug., 1902.)—These remarks concern the wave-lengths of a triplet at $\lambda = 6791$, 6878, and 7071 in the Strontium spectrum which differ from values given by Kayser and Runge in a paper not mentioned by the author in his thesis. He now shows that the difference, which is not constant, is due to the errors of achromatism of his objective; the lines in question were measured by coincidence with the green iron spectrum of the third order, and the objective was not well achromatised for these colours. This does not apply to any other lines, which were measured by coincidence with the iron lines in the blue of the second order. [See also Abstract No. 57 (1903).] E. C. C. B.

426. *Velocity of Röntgen Rays.* **R. Blondlot.** (Comptes Rendus, 135. pp. 666–670, Oct. 27, 1902. Also Electrician, Nov. 21, 1902.)—The velocity of propagation of Röntgen rays was compared with that of Hertzian waves. A Hertz oscillator with a resonator placed below it was arranged as a bridge between parallel wires which passed from the poles of an induction coil to the terminals of a focus-tube in which Röntgen rays were produced. The potential difference necessary to set the tube in action was but slightly less than that required to cause a spark at the Hertz exciter. On diminishing a very little the explosive distance of the latter the discharge did not traverse the tube, but passed entirely through the exciter. The tube ceases action at the end of a time less than a quarter of the period of the exciter. The maximum of the electric force at the gap of the resonator due to the discharge of the exciter is at the end of a half-period. When the resonator commences to oscillate the Röntgen rays are already extinguished. This was verified by experiment; the interposition of a sheet of lead between the tube and the gap did not alter the appearance of the spark. This effect was observed when the distance between the tube and the exciter was 11 cm. When the distance was increased to 25 cm. the extinction of the Röntgen rays was retarded by the time required for the Hertzian waves to traverse the extra 14 cm. of the wires. This retardation allowed time for the rays to act on the spark at the gap of the resonator. The spark was now less brilliant when a sheet of lead was interposed. By increasing the length of the transmitting wires by 38, 80, and 180 cm. successively the action of the Röntgen rays was found to be more and more distinct. On increasing the distance between the tube and the gap while keeping the length of the wires invariable, the same effect was got as when the length of the wires was increased. The rays experienced a retardation equal to the time they take to traverse the distance between the tube and the gap. This showed that their velocity is comparable with that of Hertzian waves. The paradoxical result was got that the tube acted better as its distance away was increased. On continually increasing the distance of the tube it was found that the action of the Röntgen rays passed through a maximum. It seems impossible to explain this result except by the conclusion that the velocity of the Röntgen rays is of the same order of magnitude as that of the Hertzian waves. J. J. S.

427. *Diffraction of Röntgen Rays.* **W. Haga** and **C. H. Wind.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 350–357, Sept. 27, 1902.) —The authors continue their experiments on the diffraction of Röntgen rays with an apparatus essentially identical with the one formerly used, but that some points criticised by Walter [see Abstract No. 845 (1902)] are corrected. The rays excited by means of a Ruhmkorff coil would pass first through a slit made up of two platinum plates, 2 mm. in thickness and 2 cm. in height, a lead diaphragm intercepting the interval except for a height of 4 mm.; the slit was 15 μ in width. The diffracting slit was made up of two platinum plates, ½ mm. in thickness and 4 cm. in height; it was wedge-shaped, the lower end being closed, while the upper end was about 25 μ in width. All possible care was bestowed to bringing the passages of both slits in each other's prolongation, this being particularly difficult on account of the great depth of the slit in comparison with a width so slight that ordinary light, because of the diffraction phenomena, was of no use in determining the direction of the passage, and Röntgen rays had to be resorted to. The rays, after passing through the two slits, were allowed to fall on a photographic plate, where the phenomena were registered. In the case of a rectilinear passage, a wedge-shaped image ought to be observed; now the photographs were rather thin in the middle, showing enlargements at both ends, thus giving evidence of diffraction phenomena taking place. From this fact it is inferred that Röntgen rays cannot be analogous to ordinary light vibrations. As, however, these vibrations are likely to be more complicated than luminous ones, the measurements of the wave-lengths made by the authors on the hypothesis of purely periodic vibrations give only an idea of the order of magnitude, which seems to be 0·1 $\mu\mu$. A. G.

428. *Deviable Rays of Radio-active Substances.* **E. Rutherford** and **A. G. Grier.** (Phil. Mag. 4. pp. 315–330, Sept., 1902.)—The three radio-active

substances, uranium, thorium, and radium, all emit rays which are deviable by a magnetic field and also rays which are non-deviable; differing from polonium, which gives out no deviable rays. The object of the experiments described was to obtain evidence of the connection, if any, between the deviable or β-rays and non-deviable or α-rays. It is shown that uranium gives out more deviable rays than radium or thorium, compared with the amount of non-deviable, but the ratio of the amounts of the two types of rays is of the same order. From the results of various investigators it appears that the deviable rays are similar in all respects to kathode rays, and consist of electrons travelling in some cases with nearly the speed of light. The behaviour of the different substances was tested by an electrical method, and the ionising action of the non-deviable rays was found to be much greater than that caused by the deviable rays. On investigating the variation of the amount of deviable rays with thickness of radio-active layer, it seemed that each portion of the mass sends out electrons uniformly. By different chemical methods the part responsible for the deviable radiation in both uranium and thorium can be separated from the main body, while part at least of the non-deviable radiation is unaffected. Thus it seems certain that β-rays cannot be regarded as having the same relation to α-rays as kathode rays have to Röntgen rays, which they produce; for the radio-active material which has been temporarily freed from β-rays still retains its power of giving out, in the case of uranium, a large proportion, and in the case of thorium 80 per cent. of the original α-rays. It is calculated that about $\frac{1}{8}$ of energy radiated into air by a thin layer of uranium is carried by the electrons; the ratio for thoria being about $\frac{1}{25}$ and for radium about $\frac{1}{14}$. But the greater proportion of the radiation is absorbed by the radio-active substance itself, and it is estimated that for uranium about $\frac{1}{1000}$ of the total energy radiated is carried off in the form of electrons, the ratio being still smaller for thorium and radium. It is regarded as probable that most of the deviable rays from uranium and thorium are given out by a secondary product produced by a disintegration of the uranium or thorium atom or molecule. These secondary products can be separated from the uranium and thorium by chemical means, and give rise to the active products which have been termed Ur. X. and Th. X. The non-deviable radiation may be either due to the other secondary product of the reaction, or to an action of the product responsible for the deviable rays in the mass of the radio-active material. [See also Abstract No. 222 (1903).] J. J. S.

429. *Radio-active Bismuth.* **W. Marckwald.** (Chem. News, 86. pp. 52–53, Aug. 1, 1902. From the Berichte, 35. p. 2285, 1902.)—This is a preliminary account of researches on products obtained from pitchblende obtained from the firm of Richard Sthamer, of Hamburg. The author describes how an apparently different metal was separated from bismuth by electrolysis. A fine black deposit appeared on a rod of bismuth dipped in the electrolytic solution, and this rod thus coated had a very remarkable effect in discharging an electroscope. The leaves collapsed at once when the rod was 10 cm. away. The deposit could be scraped off the bismuth plate and radio-active bismuth appears to contain only $\frac{1}{10}$ per cent. of the radio-active metal. Thus a ton of pitchblende would contain about 1 gramme. The substance is not a pure metal but contains some chlorine. The rays emitted from it are characteristically different from those of radium, as they seem unable to penetrate any intervening substance. J. J. S.

430. *Polonium.* **S. Saubermann.** (Zeitschr. Elektrotechn., Wien, 20. pp. 414–416, Aug. 24, 1902.)—Though chemical processes have hitherto been very unsuccessful in separating polonium, so that its existence apart from radium might be doubted, Marckwald has obtained a bismuth oxychloride from which pure bismuth directly precipitates a thin surface film of what appears to be mainly polonium [see preceding Abstract]. This film has an extraordinary power of discharging conductors, but its radiations have very little penetration and very slight effect upon the fluorescent screen. A. D.

431. *Induced Radio-activity in Air.* **J. J. Thomson.** (Phil. Mag. 4. pp. 352–367, Sept., 1902.)—The air which had been forced through water was found to be a very much better conductor of electricity than air in the normal state, the increase in the conductivity being surprisingly large; thus, after the circulation of the air through water had continued for about two hours, the saturation-current was more than twenty times the value before the circulation commenced. The air when once it has been modified in this way retains its new properties for a very long time; when the tank was kept closed it took several days after the stoppage of the circulation for the conductivity of the air to fall to its normal value. In air which has been modified by passing through water, the properties acquired show that a continuous production of ions must be taking place; the current gets saturated, though from the much greater conductivity of the gas the e.m.f. required to saturate it is much greater than when the gas is in the normal state. When transferred to another vessel the modified air retains some, at least, of its conductivity. The author gives the following theory in explanation of the ionising power imparted to the wire:—In consequence of the negative electrification of the wire positive ions move up to it when it is placed in the modified gas; some of these ions do not discharge to the wire, but stick close to it, forming a coating of positive electricity around it. Between this coating and the wire there will be a strong electric field tending to draw negative electricity from the wire. Now a wire even at ordinary temperatures appears from many phenomena to contain rapidly moving negatively electrified corpuscles which under ordinary circumstances remain in the wire because their kinetic energy is not sufficient to carry them beyond the attraction of the metal. When, however, there is a layer of positive electricity just outside the metal, the attraction of this on the negative corpuscles drags the latter from the wire; as the corpuscles move across the space between the coating and the wire they acquire additional kinetic energy, and if the difference of potential between the coating and the wire exceeds a certain value, they will emerge from the positive coating with sufficient kinetic energy to enable them to ionise the molecules of the gas with which they come into collision; for this to be the case the potential difference between the positive coating and the wire must exceed 2 volts. Thus, on this view, the ionising power of the wire is due to a kind of polarisation, which produces an electric field which makes the wire into a kathode emitting kathode rays of feeble penetrating power which ionise the gas in the neighbourhood of the wire. In the case of a positively electrified wire the corpuscles would tend to be forced back into the wire and thus there would be no emission of kathode rays. In a similar way the conductivity produced in air when it bubbles through water may be explained. Very minute drops of water may get mixed with the air, and if each of these gets surrounded by a layer of positive electricity, then the drops might emit kathode rays which would ionise the air in its immediate neighbourhood;

thus each little drop would act as a centre of ionisation, and thus make the air a conductor. Chemical action might lead to the appearance of negative ions on the drop surrounded by a coating of positive electricity. J. J. S.

432. *Fluorescent and Phosphorescent Diamonds.* **J. H. Gladstone.** (Chem. News, 86. p. 176, Oct. 10, 1902. Paper read before the British Association (Section G), at Belfast meeting, 1902.)—At the British Association meeting in 1859 the author exhibited five diamonds, two of which were very strongly fluorescent in sunshine, one strongly so, and two not at all. The fluorescent diamonds continued to phosphoresce for some hours in the dark. Later, the author examined a collection of very fine diamonds, not one of which showed the slightest trace of fluorescence in sunshine; he concludes that diamonds of the first water do not possess the property of fluorescence, which is therefore possibly due to impurity. Fluorescent diamonds shine most brightly when exposed to ultra-violet light. A long exposure to sunlight exhausts the power of phosphorescence for a time; this is not due to any increase of temperature. There is no discernible difference between fluorescent and non-fluorescent diamonds in regard to transparency to Röntgen rays—according to Crookes, the absorption of those rays by the colourless diamond and by the black form of carbon is the same. [See also Abstract No. 1852 (1902).] W. S.

REFERENCES.

433. *Induced Radio-activity.* **A. Sella.** (Accad. Lincei, Atti, 11. pp. 81–89, Aug. 3, 1902.)—Details are given of further measurements of radio-activity induced in metallic laminæ by effluvium discharge. [See Abstracts Nos. 1520 and 2048 (1902).]

434. *Optometrical Diagnosis.* **H. M. Bestor.** (Dioptric. Review, 6. pp. 327–332, Aug., 1902. Paper read before the Indiana Optical Society. From the New York Optical Journal.)—This is a discussion as to the relative merits in skioscopy of the static method (accommodation for 6 m. distance) and the dynamic (accommodation brought into play); the latter enables results to be obtained without a mydriatic (accommodation-paralysing drug). Practical details are given. A. D.

435. *Rotatory Polarisation of the Lines of Electric Force.* **A. Garbasso.** (N. Cimento, 4. pp. 176–185, Sept., 1902.)—The author describes the rotatory polarisation of electric waves on their being passed through slabs of wood cut parallel to the fibres and adjusted at 120° to one another. An analogy is pointed out to Reusch and Sohnke's rotation of light passed through successive laminæ of mica at 120° to one another (Pogg. Ann. vol. 138, 1869, and Math. Ann. vol. 9, 1876). [See also Abstract No. 1281 (1901).] A. D.

436. *Mirror-Scale-Readings.* **M. T. Edelmann.** (Phys. Zeitschr. 3. pp. 525–527, Aug. 15, 1902. Communicated by the Physikalisch-Mechanischen Institute.)—Apparatus is described to render this more handy, more precise, and more convenient for a number, as in schools. A. D.

437. *The Aims of Artificial Lighting.* **O. Lummer.** (Elektrotechn. Zeitschr. 23. pp. 787–794, Aug. 28, and pp. 806–813, Sept. 4, 1902. Lecture given before the Elektrotechnische Verein in Berlin, March 19, 1902.)—The lecture deals with the theoretical investigations that have been made into the question of the emission of light, and concludes with a bibliography of the subject. W. H. S.

HEAT.

438. *Effect of Sudden Cooling on Elastic Properties of Metals.* **J. Muir.** (Roy. Soc., Proc. 71. pp. 80–91, Oct. 31, 1902. Part of a thesis submitted for the degree of Doctor of Science, Glasgow University.)—Specimens of mild steel, iron, copper, brass, and aluminium were tested in tension after being quenched from known temperatures about 700° C., the strains previous to the yield-point being measured by the Ewing extensometer. In each case the material had no range of elasticity after quenching, Hooke's law being departed from at the beginning of loading and to a greater extent as the load increased. In the case of iron and steel the quenching caused an increase of the ultimate breaking load, but a diminution of the total extension. With copper there was an increase of both ultimate load and extension.

H. R. C.

439. *Development of Heat in Viscous Liquids.* **G. Jaumann.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 215–231, 1902.)—By integration of the frictional forces acting on the surface of an element the usual dissipation-function is obtained [minus, however, the term $-\frac{2}{3}\theta^2$, where θ is the expansion]: this may be written $2\mu D$, where D represents the rate of distortion, such that the condition that the element is moving as a solid body is $D = 0$. In the general case D can be expressed as $\frac{1}{2}Q^2 + \operatorname{div}\dot{V} - (d/dt)\operatorname{div} V$, where V is the actual velocity and $Q^2 \equiv \Sigma(\partial v/\partial z - \partial w/\partial y)^2$; and the heat W developed per second by friction in the space τ bounded by an unchangeable surface ω can finally be expressed by—

$$W/2\mu = \int(\tfrac{1}{2}Q^2 + \theta^2)d\tau + \int\Phi\cos(\Phi,\nu)d\omega - \ddot{R},$$

where Φ is the acceleration at the surface-element $d\omega$, at which ν is the outward normal, and R denotes the whole volume of the liquid mass which occupies the space τ.

R. E. B.

440. *Diathermancy of Liquids.* **O. Dechant.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 264–275, 1902. From the Physikalischen Institut of the University in Vienna.)—With distilled water, alum solution, and cobaltous chloride solution, the diathermancy decreases with increasing temperature, the fall in the diathermancy of water being approximately linear. Alum solution (sp. gr. 1·062, thickness 3·44 mm.) has a diathermancy only a little less than 98 per cent. that of water; the diathermancy falls off somewhat more rapidly than that of water. Cobaltous chloride solution has the least diathermancy of the three, and the diathermancy begins to fall somewhat rapidly about 50° C., when the colour begins to change.

A. D.

441. *Specific Heat of Water-Vapour.* **M. Thiesen.** (Ann. d. Physik, 9. 1. pp. 80–93, Aug., 1902. Communicated by the Physikalisch-Technische Reichsanstalt.)—The author shows that, if C_1, C_2 are the isopiestic specific heats of a vapour and its liquid at absolute temperature ϑ and under the *saturation*-pressure p, v_1 and v_2 being the corresponding specific volumes and ρ the latent heat—

$$C_1 = C_2 + d\rho/d\vartheta + \rho(\partial/\partial\vartheta)\log\{(v_1 - v_2)/\vartheta\}:$$

and he calculates the values of C_1 for water-vapour by assuming v_2 to be negligible and by taking $C_2 = 1 + 0{\cdot}0003(\vartheta - 298)^2/(\vartheta - 250)$, $\rho = 83{\cdot}45(638 - \vartheta)^{\frac{1}{3}}$, $pv_1 = 0{\cdot}1100\vartheta(1 - 1297p\vartheta^{-3})$, pressures being measured in mm. of mercury, and the saturation-pressures being given in atmospheres by—

$$\vartheta\log_{10}p = 5{\cdot}409\vartheta - 5{\cdot}08 \times 10^{-9}(638 - \vartheta)^4 - 1992{\cdot}5.$$

He thus obtains the following values for C_1 at the corresponding temperatures C. :—

0°	20°	40°	60°	80°	100°	120°	140°	160°	180°
0·4655	0·4401	0·4256	0·4171	0·415	0·421	0·436	0·457	0·483	0·51

which show a well-marked minimum between 70° and 80° C. He calculates also the corresponding values of C_0, the isopiestic specific heat at ϑ and zero pressure, and of c_1,C_0, the isometric specific heats at ϑ under saturation and zero pressures respectively, the above characteristic giving—

$$C_0 = C_1 - 856p\vartheta^{-3},\ c_1 = C_1 - 0{\cdot}11(1 + 2594p\vartheta^{-3})^2.$$

These show minima values somewhat over 80° C. [and points of inflexion about 150° C.]. A discussion of these results with reference to other experimental measures indicates that the data on which the calculations have been based are not sufficiently exact for the higher temperatures in the table.

R. E. B.

442. *Thermo-Element in a Vacuum Radiation Measurer.* **P. Lebedew.** (Ann. d. Physik, 9. 1. pp. 209–213, Aug., 1902.)—When using a thermo-element as a measurer of short electric waves, the author had already noted its much-increased sensitiveness when in a vacuum. This fact is here made the subject of a special research, the radiation being now from a Hefner lamp. The thermo-cell was formed from platinum and constantan with platinum leads through the glass walls of the vacuum chamber. The change of sensitiveness of the arrangement for different pressures was observed and the relation plotted as a semi-logarithmic curve. It is noteworthy that from pressures of about 1 atmosphere to 5 mm. of mercury the sensitiveness remains practically constant. For lower pressures the sensitiveness was much increased by further rarefaction, at about 0·01 mm., the increase being according to the seventh power for a blackened junction of the thermo-element and according to the twenty-fifth power for a bright junction. Still higher vacua were tried, but the increased sensitiveness was not sufficient to present any practical advantage sufficient to compensate for the difficulties involved. E. H. B.

443. *Vapour-Pressures of Ternary Mixtures.* **F. A. H. Schreinemakers.** (Archives Néerlandaises, 7. pp. 99–265, 1902.)—In a long paper, not well suited for abstraction, the author discusses, with the aid of the ζ surface, the phenomena that occur in ternary systems in which a vapour phase is present. Heterogeneous, as well as homogeneous mixtures are treated, the curves of evaporation and condensation being discussed and the effects on them of pressure and temperature. There are also sections on distillation, on the influence of a third component, on the state of aggregation of a binary mixture, and on the effect of foreign substances on the vapour pressures and boiling-points of binary mixtures. [See also Abstract No. 1171 (1902).]

W. E. T.

444. *Law of Distribution of Velocities of Gas Molecules.* **G. Jäger.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 255-268, 1902.)—The gas considered in this paper is the saturated vapour of a liquid. The law which the writer arrives at is Maxwell's law. The important thing to consider in any proof of this law is on what assumptions it is based, because it is known that Maxwell's law can always be proved if suitable assumptions are made. The present writer makes the following assumptions: Assumption I.—The Clausius-Clapeyron law. If v, v' denote the specific volumes of the saturated vapour and liquid respectively, $T=\frac{1}{3}m\overline{c^2}$ the temperature, p the pressure, and rJ the heat of evaporation, then the law asserts $rJ=T\frac{dp}{dT}(v-v')$. Here rJ is a certain quantity of kinetic energy, namely, 'a,' which a molecule loses in passing from the liquid into the vapour, or as we may express it, its potential in so passing is increased by 'a.' Assumption II.—The saturated vapour is a perfect gas obeying the Boyle-Charles laws. By a permissible approximation (if indeed it is such) this is expressed in the form $p(v-v')=RT$, where R is constant. This equation involves in general the assumption that there is no virial of intermolecular forces. For if there were it would be inconsistent with Clausius' virial equation. It involves therefore, strictly, the assumption that no encounters take place between the molecules. They are, as he says, so distant from each other that no one experiences any force from its neighbours. It is true, he says also, that the law of distribution is governed by the encounters. In all these limiting case investigations a certain amount of self-contradiction is venial, or even essential to the argument. We must take a statistical view, and understand by no encounters only as few encounters as may be, and so on. Combining now assumptions I. and II., the writer finds $p=e^{-\frac{rJ}{RT}}$, which he puts in the form $p=e^{-\frac{3a}{m\overline{c^2}}}$. This is equation (2) in the writer's notation. Since by assumption (II.) p varies as the density, we have an independent proof of Boltzmann's law e^{-2hx} in its general form. Assumption III.—In the liquid the law of distribution of velocities among the molecules is exactly the same in form as in the vapour. Inasmuch as the law is the same, there must in the interior of the liquid, *i.e.*, beyond the range of the capillary forces, be no kind of intermolecular forces. And this is, he says, the fact, because in the liquid the neighbours of any molecule are so close to it that the forces exerted on it by them mutually cancel each other. And this notwithstanding that the molecules have a velocity of mean square, perhaps 300 m. per sec. In the vapour there is no virial because the molecules are so far apart. In the liquid because they are so near together. This assumption III. is very remarkable, and to the unimaginative mind a very large assumption. It is, however, coextensive with the conclusion intended to be founded on it. The application to the liquid of Boltzmann's law e^{-2hx} is not considered. The line of proof is as follows: The bounding surface between liquid and vapour is taken for the plane of yz. The velocity of a molecule normal to it is u for the vapour, u for the liquid. The number of molecules having velocity $u \ldots u+du$ is $f(u)du$

for the vapour, correspondingly for the liquid $f(u_1)du_1$. Evidently per unit of time as many molecules cross the bounding surface from liquid to vapour as from vapour to liquid. By assumption I. only those molecules of the liquid whose kinetic energy is greater than "a" can pass into the vapour at all. By comparing the expressions for the pressure in liquid and vapour respectively, the writer obtains the equation—

$$p = \frac{2P\overline{c^2}}{3\bar{u}\,\overline{u_1^2}}\int_{\sqrt{\frac{2a}{m}}}^{\infty} u_1 f(u_1)du_1 = Ce^{-\frac{3a}{m\overline{c^2}}}$$

by equation (2). The constant factor $2P\overline{c^2}/3\bar{u}\,\overline{u_1^2}$ does not affect the main result. Writing $\sqrt{\frac{2a}{m}} = x$, and differentiating for x, we obtain—

$$xf(x)dx = C\frac{3}{\overline{c^2}}x\,e^{-\frac{3x^2}{2\overline{c^2}}},$$

whence $f(x)$ is proportional to $e^{-\frac{3x^2}{2\overline{c^2}}}$, and therefore also by III., $f(u)$ is proportional to $e^{-\frac{3x^2}{2\overline{c^2}}}$. Maxwell's law is thus proved, on assumptions I., II., and III.

S. H. B.

445. *Displacement of Equilibrium.* **P. Saurel.** (Journ. Phys. Chem. 6. pp. 467–478, Oct., 1902.)—The state of equilibrium of a bivariant or multivariant system is completely determined if any of the four pairs of variables, entropy and volume, temperature and volume, entropy and pressure, temperature and pressure, be given. The author deduces two theorems relating to the displacement of equilibrium corresponding to each of the above pairs of variables. Thus in addition to van't Hoff's and Le Chatelier's theorems the following analogies are proved: If, under constant volume (or under constant pressure) the entropy of a system in equilibrium be increased, there results a change in the state of the system which, if it were to take place under constant volume (or under constant pressure) and with constant entropy, would have for effect a decrease in temperature; and if, with constant entropy (or at constant temperature) the volume of a system in equilibrium be increased, there results a change in the state of the system which, if it were to take place with constant entropy (or at constant temperature) and under constant volume, would have for effect an increase in pressure.

W. E. T.

446. *Critical State of a One-component System.* **P. Saurel.** (Journ. Phys. Chem. 6. pp. 474–491, Oct., 1902.)—The author draws attention to the fact that Gibbs' memoir on the energy surface contains a general theory of the critical state of a one-component system and of the continuity of the liquid and gaseous states, which is simple and independent of molecular hypothesis. He gives a demonstration of the conditions satisfied in the critical state, and deduces the most important theorems relating to it, showing that most of Duhem's assumptions (see Traité elementaire de Méchanique Chimique, 2 147–157, 1898) are consequences of the fundamental assumptions of Gibbs.

W. E. T.

447. *Constitution of Gases.* **C. Puschl.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 187–214, 1902.)—A theory of gases is here put forward which

starts with a proposition that "the amount of energy of a gas of volume v under hydrostatic pressure p, which maintains the equilibrium of the gas, is pv," and with the hypotheses that the substance of an atom is continuous and impenetrable by ether; that this substance is in a continuous state of vibration, and therefore sets up waves of special types in the surrounding ether which the other atoms selectively reflect, though transmitting radiation in general without sensible reflexion; that these reflected rays accordingly accumulate in the space occupied by the gas, and their energy together with pv makes up what is called the whole energy of the gas. Other hypotheses are introduced as required, and the subject is treated generally and without any exact reasoning. R. E. B.

REFERENCES.

448. *Modern Work in the Thermodynamics of Energy of Radiation.* **Michelson.** (Jurn. Russk. Fisik. Chimičesk. Obščestva, 34. 5b. pp. 155–209, 1902.)—After pointing out the difficulties attending the application of the second law of thermodynamics, and the high importance of the same, a very full survey is given of modern work in the thermodynamics of the energy of radiation. A. G.

449. *van der Waals' ψ-Surface, VII.* **J. E. Verschaffelt.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 328–342, Sept. 27, 1902.)—The author continues his studies on the state-equation and the ψ-surface in the immediate neighbourhood of the critical state for binary mixtures with small percentages of one of the components. The limiting and connodal lines are first considered in some particular cases, the points studied next being the limiting line in the p, v, T-diagram for a mixture with a ratio x, the condensation phenomena, the p, T-diagram, and the critical point of contact. [See also Abstract No. 2227 (1902).] A. G.

450. *Critical Phenomena in Partially Miscible Liquids.* **J. D. van der Waals.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 396–400, Oct. 25, 1902.)—This is a discussion of Kuenen's paper on the same subject [see Abstract No. 235 (1903)], pointing out the great importance the former's researches are likely to have for further investigation of these phenomena. A. G.

451. *Law of the Linear Diameter.* **A. Batschinski.** (Zeitschr. Phys. Chem. 41. pp. 741–743, Sept. 26, 1902.)—The law of Cailletet and Mathias is deduced from van der Waal's equation with the help of Dupré's formula—

$$\operatorname{Log} p = k - m \log T - n/T$$

for the relation between vapour-pressure and temperature. [The method of deduction is not new, as it has already been employed to solve the converse problem, *i.e.*, starting with van der Waal's equation, and Cailletet and Mathias' law, to obtain a relation between vapour-pressure and temperature. (See Nature, 1896.)] F. G. D.

452. *Kinetic Theory of Heat-equilibrium and of the Second Law of Thermodynamics.* **A. Einstein.** (Ann. d. Physik, 9. 2. pp. 417–433, Sept., 1902.)—This is an attempt to deduce the laws of heat-equilibrium and the second law of thermodynamics from general mechanical principles and the theory of probabilities alone. R. E. B.

SOUND.

453. *Classification of Binary Concords.* **A. Guillemin.** (Comptes Rendus, 135. pp. 396–399, Sept. 1, 1902.)—If the concord of two notes be given by $m:n$, m and n being in the usual way the smallest whole numbers that express the ratio of the frequencies, then the *specific dissonance* of the concord is given by $m+n$ and the *specific consonance* by $\frac{1}{m+n}$. Thus for the octave the specific dissonance is $2+1$, for the fifth $3+2$, for the fourth $4+3$, and so on. A table of specific dissonances of the principle binary concords is given, the values varying from 2 for the unison $(1+1)$, to 10 for the concords $9:1$ and $7:3$. The values of the intervals are also stated in millisavarts. [See also Abstracts Nos. 80 and 81 (1903).] J. W. P.

454. *Arc-light Telephony.* **E. Ruhmer.** (Elektrotechn. Zeitschr. 23. pp. 859–862, Sept. 25, 1902.)—Progress has been made in the transmission of telephonic messages by the author's apparatus. The sending apparatus consists of an arc lamp and a parabolic reflector for concentrating the rays upon the receiving instrument, which is a selenium resistance-cell connected in series with a battery and telephone. With the improved apparatus speech has been transmitted through a distance of 7 km. It is found to be necessary to supply the arc with current, not from a dynamo, but from a steady source, either primary or storage cells. The carbons should be specially selected to give the particular radiation to which selenium is most sensitive. The parabolic mirror has also to be chosen with great care, both as regards its correctness of figure and as regards its non-absorptive qualities. The selenium cells have given some trouble on account of the falling-off of their sensitiveness under exposure. There is some advantage in enclosing them in a thin glass cover which can be partially exhausted of air. One of these cells, the most sensitive, has a sensitive surface of 18 × 23 mm. Its resistance dark is 120,000 ohms, which falls to about 1,500 ohms on exposure to a 16-c.p. glow lamp. A curve is given, showing the fall of resistance of this interesting cell with intensity of illumination. The parabolic mirror adopted is 500 mm. diameter, and has a focal length of 70 mm. As a means of examining the best form to give to the various parts of the apparatus the receiver was sometimes replaced by a kinemetograph camera. The plate when developed exhibits the undulatory state of the received radiation, and enables an estimate to be made as to whether any given modification is an improvement or not. [See also Abstract No. 1234 (1901).] R. A.

REFERENCE.

455. *Tuning-Forks.* **A. Schoenrock.** (Zeitschr. Instrumentenk., Beib. 13. pp. 123–125, July 1, and 14. pp. 135–137, July 15, 1902.)—The paper deals with the verification of a tuning-fork, and describes a direct photographic method of recording the frequency of the vibrations. A. D.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

456. *Electromagnetic Field due to Electric Convection.* **G. Picciati.** (Accad. Lincei, Atti, 11. pp. 221–229, Oct. 19, 1902.)—The author applies Hertz's theory to the case of an electric charge moving uniformly parallel to an infinite conducting plane. He refers to a memoir by Levi-Civita (Sur le champ electro-magnetique Annales de la Faculté des Sciences de Toulouse, ser. III. t. IV., 1902) in which a similar problem was treated. He proposes here to obtain the same results by a simpler method. If the given charge were moving in an infinite unpolarisable dielectric, and the electric and magnetic forces were respectively denoted by X', Y', Z', and L', M', N', these would be solutions of the system—

$$\text{I.}\ \left\{ A\frac{dL}{dt} = \frac{dZ}{dy} - \frac{dY}{dz} \right\}, \text{\&c.,} \qquad \text{II.}\ \left\{ A\frac{dX}{dt} = \frac{dM}{dz} - \frac{dN}{dy} \right\}, \text{\&c.,}$$

$$\text{III.}\ \frac{dL}{dx} + \frac{dM}{dy} + \frac{dN}{dz} = 0, \qquad \text{IV.}\ \frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz} = 0,$$

$1/A$ being the velocity of light in ether. And referring the motion to a system of rectangular axes of ξ, η, ζ, connected with the moving charge, the coordinates of which are $\xi = \eta = 0$, $\zeta = d$, and the velocity of the charge being a/A, he obtains—

$$X' = -m(1-a^2)\frac{d}{d\xi}\frac{1}{\Delta}, \ Y' = -m\frac{d}{d\eta}\frac{1}{\Delta}, \ Z' = -m\frac{d}{d\zeta}\frac{1}{\Delta},$$

$$L' = 0, \ M' = -ma\frac{d}{d\zeta}\frac{1}{\Delta}, \ N' = ma\frac{d}{d\eta}\frac{1}{\Delta}$$

$$\Delta^2 = \xi^2 + (1-a^2)(\eta^2 + (\zeta - d^2)).$$

When the plane parallel to the motion of the charge becomes a conducting plane σ, we have electric and magnetic forces of induction X, &c., and L, &c., which must satisfy the system of equations I.–IV., regular at all points in space except on σ. On that plane the tangential components of the electric forces, X, Y, are constant, the tangential components of the magnetic forces, L, &c., undergo discontinuous change in crossing the surface. The problem is to determine X_1, Y_1, Z_1, L_1, M_1, N_1—of these Z, and N, are easily determined. The others are finally obtained in terms of U_1 and V_1, $2\frac{dV_1}{d\zeta}$ being the discontinuous change of L, at the surface, and $-2\frac{dV_1}{d\zeta}$ the same for M. Hence are found the four unknowns, X_1, Y_1, L_1, M_1. The method of integration followed is that of Levi-Civita.
S. H. B.

457. *Electromagnetic Mass of Electrons.* **W. Kaufmann.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 5. pp. 291–296, 1902.)—In previous work on the magnetic and electric deflection of Becquerel rays by using Searle's formula, the author found the inertia of the electrons to be partly that of a mechanical mass. But, adopting the theory, due to M. Abraham, which discriminates between "transverse" inertia and the "longitudinal" inertia dealt with by Searle, the following results are found. The relation between electric and magnetic deflections corresponds with the theoretical expression on the assumption of a purely electromagnetic mass. The absolute value differs from the theoretical only by an amount within the limits of the possible errors of observation. E. H. B.

458. *Influence of an Electric Field on the Elasticity of Glass.* **G. Ercolini.** (N. Cimento, 4. pp. 270–279, Oct., 1902.)—The author has examined the deformation of glass under the influence of small forces of flexion, elongation, and compression, (*a*) in a constant electric field, (*b*) in the absence of electrical forces; he finds that the electric field is without sensible influence on the values of the elasticity of flexion, &c. This result is of importance as supporting the theory of deformation of condensers recently given by P. Sacerdote (Ann. Ch. et Phys. 7 Série, t. 20). D. H. J.

459. *A Problem in Electrostatics.* **E. Almansi.** (N. Cimento, 4. pp. 280–286, Oct., 1902.)—In a former note [see Abstract No. 246 (1903)] the writer discussed the problem of the quantity of electricity which passes to a small conductor q, when it is made to touch in one point m a much larger conductor Q, which is in equilibrium with a charge of electricity E. He obtained the result that if h be the density on Q at the point of contact m, e the charge that passes to q, then the ratio $K = e/h$ (1) depends only on the shape of q, and on the situation on Q of the point of contact. In the present note he treats the special case in which q is a semi-ellipsoid, having equation $\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=1$, the axis z being the common normal of q and Q at m. He supposes that ω is a small portion of the ellipsoidal surface, which coincides with the common tangent plane T at m, σ the rest of the half ellipsoidal surface, σ' the other semiellipsoid $\sigma + \sigma' = S$. Then if we have a charge on s whose potential on s is equal to z, and if u be the potential of that distribution, we have $K = \omega + \int_s \frac{du}{dz}\,dS$, the integration being over the tangent plane.

Using the known formula for the potential, u_1, of an ellipsoid of uniform density, he finds that $u = \frac{du_1}{dz}$ satisfies all the conditions, whence—

$$K = \omega + \int_s \frac{d^2u_1}{dz^2}\,dS.$$

Then he proceeds to transform K, and obtains ultimately $K = (A + B + C)\omega/C$, where—

$$A = \int_0^\infty \frac{d\lambda}{(a^2+\lambda)F(\lambda)}$$

λ is the positive root of—

$$\frac{x^2}{a^2+\lambda_1}+\frac{y^2}{b^2+\lambda_1}+\frac{z^2}{c^2+\lambda_1}-1=0$$

and $F(\lambda) = \sqrt{(a^2+\lambda)(b^2+\lambda)(c^2+\lambda)}$: B and C have corresponding meanings He gives also the modified result when $a = b = R$ and $c < R$. K being known, e is found in terms of h from equation (1). S. H. B.

460. *Water-dropper and Atmospheric Electricity.* **A. Schmauss.** (Ann d. Physik, 9. 1. pp. 224–237, Aug., 1902.)—Lenard's experiments have shown that water-drops after falling through the air and then meeting some obstruction, charge the air negatively while they themselves become positively charged. The author of this paper has investigated how this phenomena is modified by previously ionising the air through which the water has to fall, by means of Röntgen rays. The water was allowed to drop, within a metal enclosure, into a metallic cylindrical vessel suspended by silk threads within the enclosure. The obstruction on to which the water fell was placed in this vessel in electrical connection with it, and a wire from the outside of this vessel made connection with the electrometer. The experiments consisted in measuring the rise of potential of the vessel with time as basis, and then repeating the experiments after ionising the air by permitting Röntgen rays to penetrate the enclosure through a glass window for a short time before starting the flow. The curves of potential as a function of the time vary with the obstruction used. With a metallic plate as obstruction the curve is roughly parabolic in form having its axis along the axis of potential, but when the air has been previously ionised all the ordinates are diminished. The curve then first of all falls below the zero line, that is the water becomes negatively electrified, then after a short interval of time the curve begins to rise again and continues to do so until finally it becomes approximately parallel to the curve for air which was not previously ionised. This initial negative charge can be produced by the small ionisation always present in ordinary air if we diminish the rate at which the positive charge due to the splash increases, either by diminishing the rate of flow or by letting the drops fall on wire gauze or on cloth instead of on a plate. The initial negative charge is, however, always increased by previous action of Röntgen rays on the air.

These experiments confirm those of Zeleny in which he blew ionised air against an insulated conductor and found that the conductor became negatively electrified in consequence of the greater velocity of the negative ions. In the present case the experiment is reversed and the water-drops become negatively charged by falling through ionised air. The connection between this and the negative charge brought to the earth by rain will be apparent. J. B. H.

461. *Electricity at Mountain Heights.* **W. Caspari.** (Phys. Zeitschr. 3. pp. 521–525, Aug. 15, 1902.)—Observations as to the ionisation, &c., at different mountain heights (Swiss Alps). Considerations tending to show that "mountain sickness" is closely related to the proportion of free ions in the air, and that the tendency to this is therefore greater in clear weather and before a storm. A. D.

DISCHARGE AND OSCILLATIONS.

462. *Electric Discharge.* **E. Lecher.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a, pp. 513–523, 1902. From the Physikalischen Institute der k. k. Deutschen Universität of Prague.)—The electrical discharge between the terminals of a Voss machine is examined when the spark-gap is separately electrified by a circuit of wet string connected to the terminals of an induction coil. Various modifications of this arrangement are made, and the discharges are further altered by the interposition of points connected to earth. The conclusions arrived at are indefinite, being merely that the second circuit has some effect upon the nature of the discharge. Reference is made to the paper of Cook [see Abstract No. 814 (1899)]. R. A.

463. *"Singing" Arcs.* **I. K. A. Wertheim Salomonson.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 381–391, Oct. 25, 1902.)—The author criticises the method suggested by several experimenters of measuring small self-inductions by the pitch of a "singing" arc. With this method it is assumed that the frequency of the alternate currents generated, and thus the pitch of the arc as well, are dependent only on the resistance, self-induction, and capacity of the conductor through which the carbons are short-circuited. The author shows that the *intensity* of the *direct current* feeding the arc plays a prominent part in these phenomena. The method used was first described by Peukert. The p.d. at the carbons is determined both by a voltmeter responding exclusively to direct current, such as a Weston instrument, and an instrument giving the value of $\frac{1}{T}\int_0^T E^2 dt$, a hot-wire galvanometer for instance. The intensity of current in the condenser circuit is next measured by means of a thermical ampere-metre. These three readings being E_1, E_2, and f_2 respectively, and the capacity being c, the required frequency will be given by the equation $n = f_2/(2\pi c\sqrt{E_2^2 - E_1^2})$. From the numerous tables recording the results of the experiments evidence is shown that the frequency of the tone given by the arc will assume values several times higher than the initial one, as the current increases, say to twice its initial value. The author thus succeeds in reaching frequencies as high as 270,000, where no sound, of course, is heard. This rise of frequency with increase in the intensity of the direct current is compared with the rise of pitch, as observed with electrically-driven tuning-forks, it being suggested that for higher intensities of the currents the electrical system, made up of a self-induction and a capacity, no longer vibrates with its proper period, this being observed only in the case of infinitely small values of the same. Several simple formulæ are tested, a formula $\log. p = a + Cf$, where a and C are dependent on the constants of the system, being found to represent the results of the experiments fairly well, though no theoretical value is claimed for it. The author finally tests the influence of the p.d. at the electrodes on the frequency, and it is shown that the latter is diminished by raising the p.d., the amount of the decrease corresponding almost perfectly with the simultaneous decrease in the intensity of the current. If, however, only the p.d. at the electrodes be altered, the intensity of current being maintained constant by diminishing the resistance, a certain alteration of the pitch in the same is still noted. In this case, however, the intensity of the tone is equally found to be altered, together with corresponding alterations of the intensity of the alternate current, the singing ceasing abruptly above a certain value of the p.d. A. G.

464. *Influence of Becquerel Rays upon Spark-discharge.* **M. Cantor.** (Ann. d. Physik, 9. 2. pp. 452–457, Sept., 1902.)—The author has studied the influence of Becquerel rays on the spark discharge a little more in detail than it was formerly studied by Elster and Geitel. [See Abstract No. 60 (1900).] If the rays have passed through an aluminium plate they produce no effect on the sparks between aluminium electrodes, but they completely extinguish all sparks between platinum electrodes up to a distance of 30 cm. Electrodes of gold, silver, copper, brass and iron are also sensitive, but to a less degree than platinum. After passing the rays through a 7-mm. wooden board they extinguished the sparks between the electrodes up to a distance of 50 cm. in the case of platinum, and to a distance of 5 cm. in the case of aluminium, the other metals lying in sensitiveness between these two. The length of the spark-gaps used were 5 mm. and 1 mm. These were tried with each metal. Some experiments on the influence of an electrostatic field on the spark length are also described. J. B. H.

465. *Conditions Controlling Potential Fall at Electrodes in Vacuum-Tube Discharge. II.* **C. A. Skinner.** (Phil. Mag. 4. pp. 490–504, Oct., 1902. Paper read before the American Association for the Advancement of Science, June, 1902.)—In this paper the author discusses his previous experiments on the same subject, and describes further experiments [see Abstract No. 487, (1902)]. The earlier results seemed to indicate that the drop of potential at the electrodes in vacuum-tube discharge is caused by a resistance to discharge of the gas ion to the metal electrode, this resistance increasing with the velocity with which the ion impinges on the electrode. The discharging ion, then, must give up its kinetic energy with—or before it can give up—its charge. The ions approaching the electrode will accumulate at its surface until the thereby increased electric intensity becomes sufficient to cause as many to discharge in a given interval as arrive at the electrode during that interval. From this standpoint the drop of potential will depend on the time required for the discharging ions, arriving with a definite velocity, to come to rest at the electrode—their kinetic energy being first given up by collision with the neighbouring gas molecules and with the electrode. This being a mechanical explanation, the author seeks to apply the laws of mechanics to deduce theoretical results which will confirm or predict those obtained by experiment. Taking the simple ideal case of a particle of mass m with positive charge e moving *freely* in the direction perpendicular to the plane of a plane-electrode, he arrives at an equation for T, the time required for the particle to come to rest at the electrode, which, on inspection, furnishes an explanation for many of the phenomena, and he concludes that it contains the controlling factors, those ignored entering as correcting factors. If we consider the particle as starting from a point, distance s from the electrode, with a velocity u, then if V be the potential-fall along the distance s and k be the coefficient of restitution when the particle impinges on the electrode, the equation is—

$$T=\frac{2sk}{1-k}\left\{\left(\frac{m}{e}\right)^2\frac{u^2}{V^2}+\frac{m}{e}\cdot\frac{2}{V}\right\}^{\frac{1}{2}}$$

where $0 < k < 1$. In further test of his view of the cause of the electrode drop, the author has made experiments on the increase in the anode drop with increase of potential gradient in the gas, on antikathode effects, and on the effect of a magnetic field upon the electrode drop. The results of these are given, some being further explained by curves. W. C. H.

466. *Positive Electrons.* **W. Wien.** (Zeitschr. Elektrochem. 8. pp. 585–590; Discussion, p. 591, Aug. 14, 1902. Paper read before the Electrochemical Society at Würzburg, May 9 and 10, 1902.)—The paper is chiefly a *résumé* of the author's past work on the positive ions in the Geissler tube. By cutting an orifice in the kathode, the positive ions are led behind it, and the effect of magnetic and electrostatic fields on them may be investigated. It is found that some of the ions are scarcely deflected at all, and that these bring about a peculiar phosphorescence on the glass. Certain metallic oxides also show very marked colours under their action. Having taken great care to produce dryness, it was found that an evolution of gas was produced from these oxides, and spectroscopic examination showed this to

be hydrogen. In the discussion **W. Hittorf** recalled the experiments of Warburg, as showing how difficult it is to produce absolute freedom from moisture in glass vessels. **Abegg** pointed out Brereton Baker's results as showing the great influence of the smallest trace of moisture. R. S. W.

467. *Edison Phenomenon.* **M. Allegretti.** (N. Cimento, 4. pp. 161–175, Sept., 1902.)—Edison's phenomenon (1884) is that if a metallic plate be introduced into an electric incandescent lamp and joined through a galvanometer to the positive terminal of the lamp, there is a current from the positive terminal to the metallic plate. This current the author finds is stronger the smaller the distance between the plate and the filament. At high vacua the fall-off is rapid as this distance increases; at lower vacua the current tends to be proportional to this distance. The current is a maximum at lower vacua; and it increases with the area of the metal plate, but not so much as to be in direct proportion to it. There is no action upon a photographic film, covered with black paper, between the filament and the metallic plate. A magnetic field, positive or negative, produces an equal diminution in the current; the current in the gas is deviated in the same manner as kathode rays. At low vacua, the phenomenon seems due mainly to conductivity in the gas; at high vacua mainly to a kind of radiation, possibly kathodic, but of small penetrating power. A. D.

468. *Metallic Laminæ Obtained by Kathodic Projection.* **L. Houllevigue.** (Comptes Rendus, 135. pp. 626–627, Oct. 20, 1902.)—The author has prepared by this means deposits of platinum, palladium, iron, nickel, cobalt, copper, bismuth. The receiving substance (glass, metallic plate, &c.), is placed upon a large horizontal anode of aluminium, and 12 mm. above this is placed a plate of the metal to be deposited. This plate acts as kathode. The Hittorf dark space comes almost into contact with the plate on which the deposit is to be formed. The deposits obtained present all degrees of transparency according to the period of the operation. A Bismuth lamina shows *no* variation of electrical resistance in the magnetic field. Iron when so thin as to be transparent, shows the rotatory power on the plane of polarisation. J. W. P.

469. *Formation of Kathode Rays and Röntgen Rays.* **J. Semenov.** (Comptes Rendus, 135. pp. 457–458, Sept. 15, 1902.)—Semenov's assertion that the antikathode emits Röntgen rays only if it has an electric charge [see Abstract No. 2351 (1901)] has been contradicted by Tommasina, who concludes from his own experiments that Röntgen rays are emitted even if the antikathode be connected to earth. Semenov denies the legitimacy of Tommasina's deductions, and quotes experiments by Perrin and by J. J. Thomson in support of his own view. W. S.

470. *Electrical Resonance of Metal Particles for Light Waves.* **R. W. Wood.** (Phil. Mag. 4. pp. 425–429, Oct., 1902. Paper read before the Physical Society, June 20, 1902.)—The author considers the colours observed by Threlfall in metallic precipitates and those observed by himself in metallic films [see Abstract No. 1659 (1902)] to be due to the same causes. Further investigation shows that the film colours cannot be referred either to interference or refraction, and certain analogous behaviour strengthens the view that it is a case of electrical resonance. The author has succeeded in producing gold films which are permanent in air. Green, blue, violet, and

purple films of gold have been produced by the discharge from a gold kathode to a glass plate, the colour depending on the distance of the plate from the kathode and the degree of exhaustion of the tube. All of the variously coloured films can be changed into the green film by heating. This change may be regarded as due to the fusing of the resonators, since the electrical resistance of the film is reduced by the heating. The conductivity of the film is surprisingly good, a deep blue film 10 × 5 mm. large having a resistance a little over 2 ohms before, and about half that after, heating. G. E. A.

471. *Decay of Oscillatory Discharges.* **F. Beaulard.** (Journ. de Physique, 1. pp. 498–503, Aug., 1902.)—In this experimental work the author, by means of an absolute electrometer of the guard-ring type, investigates the decay of the potential differences occurring at a spark-gap through which an oscillatory discharge is passing from a condenser. E. H. B.

472. *Hertzian Waves in Storms.* **F. Larroque.** (Comptes Rendus, 134. pp. 700–701, 1902.)—When storms are very distant the Hertzian waves [see Abstract No. 2152 (1901)] have their vibrations horizontal or nearly so; when they are nearer the vibrations are vertical. The latter are direct; are the former diffracted, reflected, or secondary? Diffraction seems in any event an inadmissible explanation. A. D.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

473. *Electric Conductivity of Metallic Oxides and Sulphides.* **F. Streintz.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 345–378, 1902.)—Having investigated the conductivity of highly compressed spongy platinum and of powdered carbon [see Abstract No. 127 (1901)], the author, with the assistance of Lampa, v. Lang, v. Schweidler, and Almstedt, has formed cylindrical rods of various powdered oxides and sulphides of Pb, Mn (also Gibbs' compound $PbO_2.4MnO_2$), Ag, Cu, Cd, Hg, Fe, Co, Ni, Sb, Mo. The electrodes were pressed into the substances. The rods were cooled in liquefied gases and heated in an electric furnace; some were formed in hot moulds. None of these rods conduct electrolytically. Only the powders of electric conductors yield cohesive rods of metallic lustre and hardness; the powders of non-conductors would not cohere, nor assume metallic lustre. At ordinary temperature powders of dark-coloured substances only which cohere conduct the current metallically, and their temperature coefficients are positive, but much smaller than those of pure metals. Substances which at ordinary temperature are hardly conductors are much influenced by temperature changes (PbS, HgS, Ag_2S, MnO_2). There seems to be a particular temperature for each substance at which it becomes a conductor. If the higher oxide or sulphide does not conduct, then the lower will as a rule not conduct either; if the lower oxide or sulphide is a conductor, the higher compound (MnO_2 and Mn_2O_7, Cu_2S and CuS) will conduct better still. These last statements especially require further investigation. H. B.

474. *Variation of Capacity with Charging Potential.* **A. Schweitzer.** (Schweizerische Blätter für Elektrotechnik, 7. pp. 137–139, Sept. 22, 1902.)—The author investigates the effect of using different voltages and different durations of charge, upon the results obtained as the capacity of certain condensers and cables. In regard to mica condensers he confirms that the capacity is independent of the limits of potential, from 1 to 200 volts. [Unfortunately, he does not state the effect of differences of duration of charge in the case of mica. Also he omits to state of what material the dielectric of the cable is made.] The capacity of the cable gradually increases with time by about 0·5 per cent. from 0·5 seconds charge to 20 seconds charge. Beyond 20 seconds there is no further change noted. Similarly, there is an increase of capacity with increase of charging potential. An investigation was next made of the effect of connecting the inner and outer conductors of the cable for different periods, after charging with different potentials.

R. A.

475. *Coherers and Auto-coherers.* **O. Rochefort.** (Comptes Rendus, 134. pp. 880–881, 1902.)—Contrary to what has been believed, if imperfect contacts be pressed together, a point arrives at which there is sensibility to Hertzian waves, but a shock is required for decohesion. If the pressure be still further increased the decohesion takes place spontaneously; and on lowering the pressure in a spontaneously decohering coherer, the coherer comes to act in the ordinary way. Coherers can be so constructed that when cohered by Hertzian waves their resistance falls so as to reach the limit within which they become auto-coherers of great sensitiveness. A. D.

476. *Coherers.* **E. Drago.** (N. Cimento, 4. pp. 208–213, Sept., 1902. Atti, Acc. Gioenia di Catania, Serie 4, vol. 15.)—Coherers of PbO_2 and of CuS generally diminish in resistance under the action of acoustic waves, like those of other substances. Coherers of PbO_2, of CuS, and of C diminish in resistance with increase of the strength of the measuring current. Charging a PbO_2 coherer as an accumulator, on discharge there is a polarisation current; results uncertain with CuS and C. Coherers of PbO_2 and of CuS manifest a diminution of resistance in certain cases under the influence of electric waves. A. D.

477. *Ammeter for Large Currents.* (Electrochem. Ind., Philadelphia, 1. pp. 39–40, Oct., 1902.)—Describes a "shunt ammeter" for use in measuring large currents as used in the electro-chemical industries made by the Weston Electrical Instrument Co. This ammeter is really a voltmeter of high sensitiveness which gives full scale deflection with 0·08 volt between its terminals. It is intended to be put as a shunt between two points of a lead containing the current to be measured. In the case of the cross-section of the leads being based on 1,000 amperes per sq. in. of copper, only a length of 4½ ft. of lead will be required. The connecting wires are an integral part of the instrument, and when once adjusted must never be altered.

E. C. R.

478. *Hot Wire Ammeters.* **Kollert.** (Elektrotechn. Zeitschr. 23. pp. 384–386, 1902.)—The author discusses the relation between the current, and increase of length in wires, on a theoretical basis. Hankel, in 1848, gave the following relation: $c(1-hC^2/H)=HS$, where c is current, S deflection (proportional to increase in length of wire), and h and H constants. The author works out the relation and obtains the same expression, but with a positive sign before the second term. He finds this to give results consistent with experiment. G. H. B.

479. *Cell for Measuring the Resistance of Liquids.* **W. W. Dinwiddie.** (Phys. Rev. 15. pp. 237–238, Oct., 1902.)—A glass tube of uniform bore is cut and the ends ground to an exact length of 1 m. Short pieces of tube of a much greater diameter, with the ends sealed and a large hole blown out in the side, are fitted on the ends with corks. Flat amalgamated plates of copper, placed in close contact with the ends of the tube form the electrodes. The tube is weighed with two small discs of glass to cover the ends, it is then filled with water and again weighed. Mercury may be used in place of water, in which case it can be poured out and weighed alone. From the weight of water or mercury the mean cross-section of the tube can be found. The tube is then filled with the electrolyte to be experimented in, the ends closed by the copper electrodes, and the resistance measured by Kohlrausch's method. The resistance of the electrodes and connecting wires must be first determined by placing them together, and the difference will give the resistance of the liquid in the tube. E. C. R.

ALTERNATING CURRENTS AND MAGNETISM.

480. *Electromagnetic Rectifier.* **G. H. Morse.** (Elect. World and Engineer, 40. p. 85, July 19, 1902.)—One pole of an alternate-current circuit is connected to an arc-lamp carbon, opposite which are a pair of carbons connected to the circuit in which the rectified current is to flow. To the middle of this circuit is connected the other pole of the alternate-current circuit. The circuit is completed through the arc which is used as a commutator, and is moved from one to the other of the pair of carbons by a permanent magnetic field. With an arc one-tenth of an inch long, the current was entirely rectified. G. H. B.

481. *Phase Difference.* **E. Orlich.** (Elektrotechn. Zeitschr. 23. pp. 543–544, June 19, 1902.)—The definition of power-factor as the cosine of the phase difference between voltage and current is only strictly applicable to sinusoidal currents. It is shown that if the currents are not sinusoidal, the power-factor is equal to unity only if the phases of all the components of the curves coincide in phase and the coefficients of the various harmonics are proportional. If the forms of the voltage and current curves are different, the phase difference ϕ may be defined by the expression—power-factor $= \cos\phi = Q/Q_m$ where Q is the true power and Q_m is the maximum value of Q. But Qm may differ considerably from V_eE_e. A. E. L.

482. *Non-sinusoidal Currents.* **M. Ascoli.** (Elettricista, Rome, 11. pp. 191–197, Aug., 1902.)—A discussion of the effects of capacity and self-induction on non-sinusoidal currents. It is shown that the power-factor will be equal to unity only for the case where both voltage and current curves are similar as well as in phase. [See also preceding Abstract.] A. E. L.

483. *Magnetisation and Electric Conductivity.* **G. Barlow.** (Roy. Soc., Proc. 71. pp. 30–42, Oct. 17, 1902.)—This phenomenon is called the longitudinal or transverse effect, according as the lines of force act along or across the wires whose conductivity is considered. Unless otherwise stated the following account deals with the former. The object is to obtain a more exact determination than the many previous investigators of this relation for iron and nickel. Suppose nickel to be under investigation. Two steps are taken. (1) To determine the magnetic intensity for each field used, seven pieces of

nickel wire, 65 cm. long, are enclosed in a thin glass tube round which a coil is wound and the tube was placed in the axis of a magnetising coil 1 m. long. Intensity was measured by the ballistic method. Before every measurement the wires were demagnetised by reversals. (2) To determine change in resistance for each field used. A resistance P of nickel consists of two complete turns wound longitudinally on a thin rod of wood 65 cm. long. A comparison coil Q, of copper, whose resistance is the same as that of P, is wound in an exactly similar way on the rod. The coils being covered with wool are placed in a tube which fits into the magnetising solenoid. A water-jacket is between the coil and the core. A preliminary experiment shows that the resistance of Q is not effected by magnetisation changes; this was proved by leaving only Q in the solenoid. If $\Delta\phi$ is the change in resistance corresponding to change in intensity I, a relation stated by Gray and Jones was $\Delta\phi = aI^4$. The author suggests as a nearer approximation—

$$\Delta\phi = aI^2 + bI^4 + cI^6,$$

and he gives the values of the constants a, b, and c for iron and nickel. When $\Delta\phi$ is plotted against I, the curve has the form of a semi-cubical parabola. Hysteresis shows itself in quite symmetrical curves for iron, steel, and nickel. Except for a very small amount shown at the bottom of the curves, the value of $\Delta\phi$ is always positive, whether the field be + or —. In addition to the above, various tests were made in very high fields, up to 18,000 c.g.s. for longitudinal and transverse effect. The results are given.

P. E. S.

484. *Attractive Force and Magnetic Induction.* **G. E. Poucher.** (Phys. Rev. 15. pp. 233–236, Oct., 1902.)—The force between a magnet and its keeper is $SB^2/8\pi$, where S = cross-section of magnet and B = induction. This research is made to test the law when the object is separated from the magnet by more or less distance. A copper bar rests horizontally on knife-edges and an iron sphere 4 cm. diameter hangs from the centre of the bar over a vertical iron rod which can be magnetised to any required value of B. The force of attraction is measured by the movement of the bar, as observed in a microscope. The conclusion arrived at is that the above formula does not hold for objects at a distance from the magnet; but yet the induction and attraction bear a constant relation to one another. P. E. S.

485. *Magnetic Expansion and Electric Resistance.* **W. E. Williams.** (Phil. Mag. 4. pp. 430–435, Oct., 1902.)—Nickel is the metal under investigation. It has been previously shown by Nagaoka and others how (1) the length, and (2) the resistance, changes with magnetisation. But no one seems to have shown, by research on the same specimen of metal under the same conditions, the intimate relation existing between the expansion and the resistance. The author investigates this point by placing a long thin nickel wire in a solenoid and determining the resistance and expansion in the usual ways, taking care that the tension on the wire is definitely known in every case. The curves drawn show that there is remarkable similarity in the behaviour of the variables in question (though increase in field increases resistance and decreases length); also there is residual change in length and residual change in resistance when the field is removed and the curves for these residual amounts also bear a very close resemblance to one another.

P. E. S.

486. *Effect of Magnetisation on Elasticity.* **K. Honda, S. Shimizu,** and **S. Kusakabe.** (Phil. Mag. 4. pp. 459–468, Oct., 1902.)—Previous observers have shown that Young's Modulus is increased by magnetisation. The present research, while confirming these results, shows more clearly than before the true relation between the variables and also indicates a small decrease in elasticity for weak fields in all the metals tried. The modulus is ascertained by the method of flexure of a rod. The rod is placed horizontally on knife-edges, one magnetising coil surrounds it on the right and another on the left, while a gap remains at the centre for the application of load and for measurement. An optical lever method is used for measuring the movement, the unit of scale representing one-sixth of a micron movement. The magnetic expansion was measured for every specimen used, as this was found to have an intimate relation to the change in elasticity. The general course of the curves resembles that of magnetisation, *i.e.*, if $E =$ elasticity the relation $\delta E/E$ to H gives curves like those of I to H. There is at first a small depression of the curves, followed by a steep rise, and finally a slow progress to an asymptotic value. Soft iron and wolfram steel have curves almost identical; so have steel and nickel, the value $\delta E/E$ being less, while for cobalt the value of $\delta E/E$ is still less. P. E. S.

487. *Influence of Temperature Change on the Magnetisation of Liquids.* **G. Piaggesi.** (N. Cimento, 4. pp. 247–269, Oct., 1902.)—The author's apparatus consisted of a U-tube in which the liquid was so placed that the meniscus in one limb of the tube was in the centre of the magnetic field. A displacement of the meniscus occurred on magnetisation of the field and this displacement was measured and used in the calculation of the magnetic susceptibility K by Quincke's formula. The author's data show that—(1) for water the diamagnetism diminishes with increasing temperature and is a linear function of the temperature; (2) the magnetic susceptibility of water for temperatures between 23° and 86° C. is expressed by $K = -0{\cdot}804(1 - 0{\cdot}001 + 5\,.\,t)\,.\,10^{-6}$; (3) the magnetic susceptibility of a solution decreases with increase of temperature; (4) the coefficients of temperature for the solutions studied (iron, nickel, cobalt, and manganese salts) are almost equal and of the same order of magnitude as the dilatation coefficient of gases; (5) the product, $\theta\,.\,K\,.\,10^6$ (where θ is the absolute temperature), equals a constant, the value of which depends only on the nature and the concentration of the solution, in accordance with the law already proved by Curie for oxygen and sulphate of iron; (6) the product $\theta\,.\,K\,.\,10^6$ diminishes with the concentration of the solution. D. H. J.

488. *Meteorological Character of the Variations of Terrestrial Magnetism.* **A. Nippoldt.** (Terrestrial Magnetism, 7. pp. 101–113, Sept., 1902.)—The author submits to harmonic analysis the declination data for the year August, 1882, to July, 1883, of the following stations: Pavlovsk, Tiflis, Wilhelmshaven, South Georgia, Greenwich, Fort Rae, Vienna, Batavia, and Mauritius, deriving in each case twelve coefficients from twelve monthly series, and calculating maximum amplitudes, phases, and waves for the first, second, and third orders. This is, on the whole, sufficient. It results that the first order wave differs essentially from the second and third order waves, as G. Sack had proved for Greenwich and San Mayen. There seem to be two components for the daily variations, corresponding respectively to the solar and the terrestrial climates, while the total variation corresponds to the physical climate, and is, therefore, meteorological in character. The mag-

netic field is probably electrical in nature. The electric currents would depend upon the conductance of the air, and hence upon its meteorological conditions (density, humidity, temperature, ionisation, &c.). The direction and intensity would further vary with the primary cause, which may be cosmical, solar, or terrestrial. Quantitatively, the problem of interconnection might be approached with the aid of a simple coefficient law such as: "The variations of the secondary element depend upon those of the primary element in the same way as the absolute values depend upon one another." In order to ascertain whether the magnetic variations can entirely be due to electric currents in the atmosphere, we might determine the conductance of the air and the fall of potential under different meteorological conditions. The coefficient law would then give the coefficient for any current intensity, provided the potential and conductance be known for one intensity. Such experiments would not involve any assumption as to the cause of the change, difference in latitude, elevation, periodical effects, &c. But the induction effects in the earth would at once complicate the problem. H. B.

ELECTROPHYSIOLOGY AND ELECTROTHERAPEUTICS.

489. *Electricity in Plants.* **C. Ries.** (Phys. Zeitschr. 3. pp. 520–521, Aug. 15, 1902.)—When a leaf is partly lighted, partly darkened, and galvanometer terminals (zinc) connected with its ends, there is a current from the lighted part through the galvanometer (Waller, 1900). The author finds that this action does not depend upon the colour of the leaf; that if copper or silver terminals be used, the current is the other way; that if the electrodes are very clean there is no current or little; that if one-half of the leaf is lit while both electrodes are shaded there is no current; that red rays favour a current from the illuminated part, blue rays favour one from the darkened part of the leaf to the galvanometer; that if the terminals are brought to the expressed juice of the leaf the results are the same; that the K, Na, Ca salts in the leaf are the leading factors, while chlorophyll assists. [See also Abstract No. 116 (1901).] A. D.

REFERENCES.

490. *Electrical Standards: Report Brit. Assoc. Committee.* (Elect. Engin. 30. pp. 523–524, Oct. 10, 1902.)—This is a report as to the transfer of apparatus to Bushey House and making certain comparisons. Mercurous sulphate from different makers is found to give different results. Air-condensers, platinum thermometers, and the ampere balance have been worked at. A. D.

491. *Discharge of Parallel Conductors.* **A. Garbasso.** (N. Cimento, 3. pp. 372–382, May, 1902.)—The problem of the discharge of a condenser consisting of *n* parallel wires is developed mathematically. If the resistance of each wire is proportional to its self-induction, the system of wires is equivalent to a single conductor. A. D.

492. *Magnetic Properties of Rare Metals.* **S. Meyer.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 38–41, 1902. From the Physikalischen Institute of the University in Vienna.)—This is in the form of a note, details not being given. The sesquioxides of Europium, Gadolinium, and Samarium are tested as regards permeability, and comparison is made between them and other rare elements, Cerium, Erbium, Ytterbium, &c. P. E. S.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

493. *Law of Atomic Weights.* **G. Johnstone Stoney.** (Phil. Mag. 4. pp. 411–416, Sept., 1902.)—A letter to the editors, embodying a paper submitted by the author to the Royal Society in 1888, but not published in the Transactions, and a diagram circulated at the subsequent meeting of the British Association. It suggested "two nearly coincident laws" applicable respectively to elements of odd and of even valency, and connected the values of the atomic weights by certain definite equations and curves. The diagram as now amended includes all the elements since discovered, and arranges them in a logarithmic spiral with quadrants alternately electropositive and electronegative. The cardinal feature is that the atomic weights are represented by the volumes of concentric spheres. In a note dated August, 1902, the author gives the preference to an elliptic spiral closely similar to the logarithmic. S. R.

494. *Atomic Weight of Lanthanum.* **B. Brauner** and **F. Pavliček.** (Chem. Soc., Journ. 81. and 82. pp. 1243–1269, Sept., 1902.)—The authors conclude that lanthanum is not a mixture of elements, but has an atomic weight La = 139·04. The earlier determinations were vitiated by an error which tends to lower the atomic weight and diminishes as the basicity of the earth decreases in those cases in which a synthetical sulphate method was employed. S. R.

495. *Intramolecular Atomic Transposition with Halogen Acetanilides. II.* **I. I. Blanksma.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 378–381, Oct. 25, 1902.)—In a preceding paper the author has shown that the conversion of acetyl-chloranilide in formic acid under the influence of hydrochloric acid occurs according to the laws of a monomolecular reaction. [See Abstract No. 121 (1903).]—He now investigates the influence of the dilution of the formic acid, different amounts of hydrochloric acid being further added. It is evident from the results obtained that (1) the velocity of reaction will increase in formic acid as well as in alcoholic solution as water is added; (2) that by augmenting the amount of the catalyser the velocity of reaction is increased to a high degree; (3) that the same velocity in water free from hydrochloric acid is = 0, viz., that the body is stable in it (provided the influence of light be eliminated). It is further shown that the velocity of transposition in formic acid is greater than in alcohol. In both of these solvents the velocity is zero or, in any case, very small, when HCl is absent. A. G.

496. *Molecular Transformation.* **J. D. van der Waals.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 391–396, Oct. 25, 1902.)—It is known that in formic acid, which has to be considered as a mixture of single and double molecules, the number of double molecules will be found to decrease, as this body is investigated in the saturated vapour state at increasing temperatures. The same is true of NO_2. Now the author shows that this is by no means the only possible behaviour, the inverse occurring as well. It is suggested that with the molecular transformation of acetaldehyde and paraldehyde, as investigated by B. Roozeboom [see Abstract No. 513 (1903)], this inverse behaviour may possibly take place. The author arrives, from theoretical considerations, at the result that, "if the heat evolved by condensation to *n*-fold molecules be as great as to exceed by far $(n-1)f\mathrm{T}_{cr}$ (as in the case of formic acid) the dissociation of the saturated vapour will increase with increasing temperature. If, however, this amount of heat be much smaller than the above term, the inverse will take place." This may possibly account for the anomalies observed in the case of alcohols, water, &c. It is probable that a minimum number of double molecules exists in the case of formic acid; this, however, would be difficult to prove by experiment, as the density of the saturated vapour at this temperature (which is likely to be intermediate between $0{\cdot}8\ \mathrm{T}_{cr}$ and $0{\cdot}9\ \mathrm{T}_{cr}$) is too great to allow of investigations being made. A. G.

497. *Manufacture of Oxygen by Fractional Evaporation of Liquid Air.* **C. Linde.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 1173–1176, Aug. 9, 1902. Paper read before the 43rd meeting of the Vereines deutscher Ingenieure at Düsseldorf, 1902.)—The boiling-point of oxygen (—182·5°) lies 13° above that of nitrogen (—195·5°), and although liquid air contains the gases in their normal atmospheric proportions, fractionation takes place when the liquid is allowed to evaporate. The first gaseous fraction contains only 7 per cent. of oxygen, but the liquid becomes steadily richer in oxygen, and the last fraction to evaporate is almost pure oxygen. To obtain a gas containing 33 per cent. O_2 48 per cent. of the liquid must be allowed to evaporate, whilst a gas containing 50 per cent. O_2 is only obtained after allowing 65 per cent. of the liquid to escape. As the liquefaction of 1 cub. m. of air requires at least 2 h.p.-hours this process would be quite impracticable if the escaping gas were not utilised. Sketches are given of two forms of apparatus suitable for this purpose, and also of a large 150-h.p. plant erected at Munich by the Linde Ice-Machine Company. The apparatus consists essentially of two parts—(1) a regenerator, and (2) an evaporator. In the regenerator the escaping gases are made to circulate through a very large series of spiral channels before finally passing into the air or gas-holder; inside the spiral channels are stout pipes in which compressed air at 2 or 3 atmospheres is forced in the opposite direction, *i.e.*, from the outside to the inside of the spirals; by this means the cooling effect of the escaping gases is completely utilised and the compressed air reaches the interior of the apparatus at a temperature not much above —180° C. In the evaporator the compressed air is liquefied by passing through a series of vertical pipes surrounded by chambers containing liquid air; the liquid air evaporates, but derives the necessary latent heat of evaporation almost entirely from the compressed air of which almost an equal quantity is therefore liquefied; the deficiency is made good from a separate liquid air plant. The evaporator is placed inside the coils of the regenerator, and is therefore very effectively insulated from the outside air, and care is taken that all connections, &c., are made from the top, so that the cold air shall not be able to escape from the bottom of the well containing the evaporator. The evaporation of the liquid air is carried out continuously in seven chambers placed vertically above one another; as it flows from one to the other and is partially evaporated (by means of vertical pipes containing cold compressed air from the regenerator) the proportion of oxygen in the liquid increases until when the lowest chamber is reached it contains $\frac{1}{3}$, $\frac{1}{2}$, or $\frac{2}{3}$ by volume of gaseous oxygen; the gas from the first six chambers is largely nitrogen, whilst that from the seventh chamber is rich in oxygen. The yield of

enriched gas per h.p.-hour depends on the size of the plant and on the proportion of oxygen required as shown in the table. In a large plant the regenerative system increases the yield about twelve-fold as compared with simple non-regenerative evaporation of liquid air :—

Gas Produced per Hour.	Gas Produced per h.p.-hour.		
	Oxygen = $\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$
1 c.m.	0·32 c.m.	0·16 c.m.	0·08 c.m.
10 „	0·86 „	0·43 „	0·21 „
100 „	2·00 „	1·00 „	0·50 „
1000 „	3·40 „	1·70 „	0·85 „

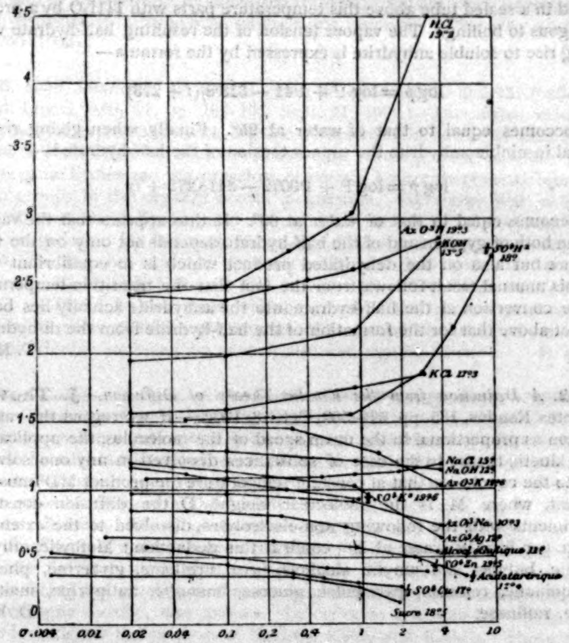
A description is further given of a fractionating column for use with liquid air, similar in principle to those used for rectifying alcohol; when these are fed even with enriched gas the volatile fraction escaping from the top of the column contains (like that from ordinary liquid air) only 7 per cent. O_2, and whilst the total yield of oxygen is not greater than with the evaporator already described it can be obtained with very much less admixed nitrogen, the maximum possible yield of 100 per cent. oxygen being about 1 c.m. from 6·6 c.m. of air. T. M. L.

498. *Probable Existence of a New Carbide of Iron, Fe_2C.* **E. D. Campbell** and **M. B. Kennedy.** (Iron and Steel Inst., Journ. pp. 1–8, Sept., 1902.)—A sample of charcoal pig-iron containing combined carbon 3·53 per cent. graphitic carbon 0·01 per cent., was annealed by slow cooling from 950°, whereby the graphitic carbon was increased to 0·12 per cent. The iron was then dissolved by making it the anode in a cell containing N/4 sulphuric acid and the carbide collected on successive days. The carbide was in the form of a fine black powder which easily passed a sieve with 100 meshes to the inch, but was largely retained by a 200-mesh sieve. It contained carbon and iron in the ratio 8·20 C : 91·80 Fe, whilst Fe_3C requires only 6·67 per cent. C, and Fe_2C would require 9·67 per cent. C. The amount of carbon recovered in this form was 80·76 per cent. of the total and the product behaved chemically in a similar way to the well-known carbide Fe_3C, yielding similar hydrocarbons when acted on by hydrochloric acid: it is suggested, therefore, that the product contained a carbide Fe_2C, mixed with about an equal weight of the carbide Fe_3C, which is the principal form of carbon contained in mild annealed steels containing less than 1 per cent. of carbon. T. M. L.

499. *Absorbent Powders in Contact with Saline, Alcoholic, or Dilute Acid Solutions.* **T. Martini.** (Rivista Sci.-Industriale, 34. pp. 125–126, Sept. 30, 1902.)—Lagergren has already studied the action of pulverulent substances in aqueous solutions and found that some substances increase (negative absorption), others diminish (positive absorption) the concentration of the solution; he connects the phenomena with the varying pressures which occur at and near the surface of the powder, and which may be supposed to cause migration of substance from places where the pressure is high to others where it is lower. The experiments, of which a brief *résumé* is given by the author, do not appear to support Lagergren's views. It was found, using animal charcoal and anhydrous silica as the absorbents, that the same powder could show positive or

negative absorption according to the concentration of the solution. With a particular solution it was found possible to obtain positive or negative absorption according to whether animal charcoal or silica was introduced; yet these two absorbents show otherwise similar phenomena of humidity. Animal charcoal extracts water even from a 99 per cent. solution of alcohol. Well-dried silica concentrates dilute solutions of sulphuric acid. D. H. J.

500. *Studies on Diffusion.* **J. Thovert.** (Annal. Chim. Phys. 7. pp. 366–432, July, 1902.)—The contents of this paper on the optical method of studying the diffusion of liquids have already been given in part in Abstract No. 482 (1902) which describes the mathematical basis of the method, and in Abstract No. 2120 (1902), which tabulates the results of experiments on the retrograde diffusion of electrolytes. In the present paper there is a fuller mathematical exposition of the subject; details of experimental data and methods are also given. A bibliographical appendix includes short *résumés* of all the principal *mémoires* on the subject since the year 1884. The above Figure is a graphic representation of the experimental results in the form of curves which show the variation of the coefficient of diffusion, D, with the concentration: the values of D × 10^5 are given as ordinates, the logarithms of the concentrations as abscissæ. D. H. J.



501. *Gypsum.* **J. H. van't Hoff.** (Zeitschr. Elektrochem. 8. pp. 575–578; Discussion, pp. 578–579, Aug. 14, 1902. Paper read before the German

Electrochemical Society, May 10, 1902, at Würzburg.)—Calcium sulphate occurs naturally as gypsum, $CaSO_4 . 2H_2O$ or as anhydrite, $CaSO_4$; by heating the former with nitric acid it is converted into the half-hydrate, $CaSO_4 . \frac{1}{2}H_2O$, apparently identical with plaster-of-Paris; "dead-burnt" plaster-of-Paris, *i.e.*, gypsum which has been overburnt and lost the whole of its water, will not set, and appears to be identical with or similar to the mineral anhydrite; by heating to 1,100°, however, it is converted into "Estrich-gypsum" which has been used for a very long time in place of mortar, sets slowly in the course of about three days, and is much harder and closer than ordinary plaster, and more soluble than "dead-burnt" plaster.

The vapour pressure, p, of gypsum, $CaSO_4 . 2H_2O$, can be expressed by the formula $\log p = \log P + 1{\cdot}493 - 567{\cdot}7/(t + 273)$, where P is the vapour pressure of water; at 107° the vapour pressure is equal to that of water, and gypsum heated in a sealed tube above this temperature parts with $1\frac{1}{2}H_2O$ by a process analogous to boiling. The vapour tension of the resulting half-hydrate when giving rise to soluble anhydrite is expressed by the formula—

$$\log p = \log P + 1{\cdot}41 - 518{\cdot}8/(t + 273)$$

and becomes equal to that of water at 95°. Finally, when giving rise to natural insoluble anhydrite the vapour tension of the half-hydrate is—

$$\log p = \log P + 1{\cdot}0072 - 341/(273 + t)$$

and becomes equal to that of water at 60°. It thus appears that the vapour tension both of gypsum and of the half-hydrate depends not only on the temperature but also on the dehydrated product which is in equilibrium with it; this unusual result follows from the fact that the transition-temperature for the conversion of the half-hydrate into the anhydride actually lies below and not above that for the formation of the half-hydrate from the di-hydrate.

T. M. L.

502. *A Deduction from the Kinetic Theory of Diffusion.* **J. Thovert.** (Comptes Rendus, 135. pp. 579–580, Oct. 13, 1902.)—If we regard the rate of diffusion as proportional to the mean speed of the molecules, the application of the kinetic theory to the case of substances dissolved in any one solvent, leads to the conclusion that at constant temperature the product MD^2 must be constant, where M is the molecular weight, D the diffusion constant. Experiments with the following non-electrolytes, dissolved to the extent of 2·5 gm. per litre in water at 18°, confirm this deduction: Methylic, ethylic, propylic, butylic, and amylic alcohols, urea, urethane, glycerine, phenol, hydroquinone, resorcin, pyrogallol, glucose, mannite, antipyrine, maltose, lactose, raffinose.

D. H. J.

503. *Colloids of Zirconium compared with those of Other Metals of the Fourth Group.* **J. H. Gladstone** and **W. Hibbert.** (Chem. News, 86. p. 175, Oct. 10, 1902. Paper read before the British Association (Section B) Belfast Meeting, 1902.)—Zirconium tetrachloride reacts with water to form hydrochloric acid and various oxychlorides or hydroxides. The gummy mass, so obtained, when dried gave beautifully regular forms of fissures and spirals; on heating the solution a jelly was obtained which, when exposed to air, gradually lost water, and when soaked in water gave up crystalline oxychlorides and then more irregular crystals free from chlorine. The zirconium colloid resembles those of silicon, tin, and titanium.

T. M. L.

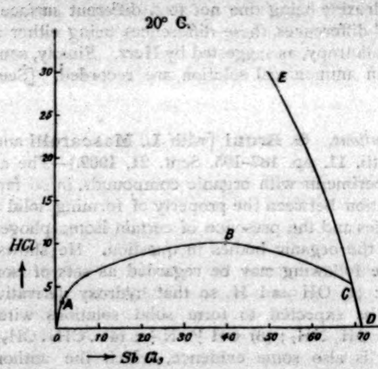
504. *Dialytic Experiments with Metal Hydrates.* **W. Herz.** (Zeitschr. Anorg. Chem. 32. 3. pp. 357–359, Oct. 13, 1902.)—Kahlbaum's liquid stannichloride diluted with water, and containing an excess of sodium hydroxide, when brought into the inner vessel of a dialyser, shows the following phenomenon: The tin will traverse the diaphragm, so as to be precipitated as yellow SnS_2 in the outer vessel, after adding hydrogen disulphide. Antimony will behave in a similar manner, this element being analytically related with tin. From other experiments with dried zinc hydroxide, the author infers that hydroxides on being dried will undergo chemical alterations of the molecular magnitude, the difference in the solubilities of the recently precipitated and the dried zinc hydroxide being due not to a different surface condition, but rather to chemical differences, these differences being either a dishydration (Hantzsch) or an allotropy, as suggested by Herz. Finally, some experiments with hydroxides in ammoniacal solution are recorded. [See also Abstract No. 1750 (1902).] A. G.

505. *Solid Solutions.* **G. Bruni** [with **L. Mascarelli** and **M. Padoa**]. (Accad. Lincei, Atti, 11. pp. 187–195, Sept. 21, 1902.)—The author resumes his cryoscopic experiments with organic compounds, in so far as they serve to show a connection between the property of forming solid solutions with other organic bodies and the presence of certain isomorphogenous atoms or atomic groups in the organic bodies in question. He shows that in some cases, at least, the following may be regarded as sets of isomorphogenous atoms or groups : (1) OH and H, so that hydroxy derivatives of organic compounds may be expected to form solid solutions with the mother-substance; (2) H, OH, NH_2; (3) $CH\vdots$, $N\vdots$; (4) $.CH_2.CH_2.$, $.CH:CH.$, $.C\vdots C.$ There is also some evidence, which the author proposes to increase, to show that the phenomena of isomorphism exhibited amongst inorganic double salts can be proved also for organic bodies. D. H. J.

506. *Catalysis of Salts of Super-Acids.* **L. Pissarjewski.** (Zeitschr. Anorg. Chem. 32. 3. pp. 341–347, Oct. 13, 1902.)—In the course of his researches on the conductivity of the salts of super-acids, the author found some of the salts to evolve oxygen, on being touched with platinised platinum electrodes, an effect very strong in some cases, nearly insensible in others. On the other hand, some of these acids as well as their salts would liberate hydrogen dioxide. These phenomena suggested the hypothesis that the catalytic effect might depend upon the degree of decomposition of the super-acids into the corresponding acids and H_2O_2, the velocity of the catalytic reaction being the greater, as this decomposition, viz., the concentration of free hydrogen dioxide, was greater. In order to test this hypothesis, the author investigates the catalysis of $NaBrO_3$, KVO_4, and $K_6V_2O_8$. The experiments were made in an Ostwald's conductivity vessel at a temperature of 25°, the platinised platinum electrodes serving as catalysers. The vessel was placed in the thermostat in a somewhat inclined position, so as to prevent the oxygen bubbles from remaining below the electrodes. From time to time, 2 c.c. from this solution would be titrated, the concentration of free H_2O_2 being at the same time determined by shaking with ether. The results fully warrant the above hypothesis. A. G.

507. *Action of Water on Antimonium Chloride.* **F. M. van Bemmelen.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 374–378, Oct. 25, 1902.) —The author applies the phase-rule method suggested by B. Roozeboom to

an investigation of the system Water + Antimonium Chloride + Hydrochloric Acid. The accompanying illustration gives an idea of the concentration of the different solutions, which at 20° are in equilibrium with the observed solid phases, all being calculated in Mol. $SbCl_3$, and Mol. HCl to Mol. H_2O. From the origin, the triple-line OA indicates the points, where the second oxychloride $Sb_4O_5Cl_2$ is the solid phase, A being the quadruple point, where the solid phase SbOCl is first observed. The HCl percentage is first greater than that of $SbCl_3$, no limiting percentage, however, being observed. With a percentage of ± 9 Mol. another quadruple point is likely to exist, a new solid phase being observed at the same time; this phase, which is likely to be a compound of SbOCl with $SbCl_3$, is in equilibrium with the solutions containing increasing amounts of $SbCl_3$, as indicated by the triple line BC. The curve will next cut at C the triple curve DCE, representing the solutions containing HCl, which at 20° are in equilibrium with the solid phase $SbCl_3$. D is the point corresponding to the saturated solution of $SbCl_3$ in water. As the percentage of HCl augments the amount of Sb will decrease, though very little, hydrochloric acid thus diminishing the solubility of $SbCl_3$ in water. E is very near the point corresponding to a saturated HCl solution, while C practically coincides with a quadruple point, where both the new compound and $SbCl_3$ are in equilibrium with the same solution. A. G.



508. *Solubilities of Carbon Compounds and the Densities of their Solutions.* **C. L. Speyers.** (Amer. Journ. Sci. 14. pp. 293–302, Oct., 1902.)—Measurements were made of the solubility at different temperatures of urea, urethane, chloral hydrate, succinimide, acetamide, acetanilide, benzamide, resorcinol, naphthalene, acenaphthene, phenanthrene, and p-toluidine in water, methyl ethyl and propylalcohols, chloroform and toluene. The densities of the saturated solutions were also determined. In several cases it was noted that the order of solubility of a substance in two solvents changes with the temperature; chloral hydrate is more soluble in toluene than in chloroform at 40°, but less soluble at 30° and below; acetanilide is more soluble in alcohol than chloroform at 0°, less soluble at 20° and above; acetamide is more soluble in alcohol than in water at 60°, less soluble at 40° and below. From the density of the solutions the molecular solution volume of the solute was deduced for different solvents and different temperatures. The variations are very considerable, and in aqueous and to some extent in alcoholic solutions the values are very high, especially at low temperatures. The values for chloroform solutions exhibit a remarkable constancy, in spite of considerable changes in temperature; those for toluene solutions are somewhat less constant. T. M. L.

509. *Velocity and Structure of the Nucleus.* **C. Barus.** (Amer. Journ. Sci. 14. pp. 225–236, Sept., 1902.)—The author gives the results of experiments on nucleation and nuclear velocities with a variety of solvents and solutes. Neutral organic solutes seem, as a class, to be distinct from saline or acid solutes, the nucleation being only half as great. The suggestions made in previous papers are further discussed, and the inference confirmed that condensation nuclei in a nearly saturated medium are concentrated solutions; as the medium is less saturated they may pass into the dry solute, if such be present. Finally, the results are compared with the researches of Lenard on the electricity produced by jets and waterfalls. (Wied. Ann. 46. pp. 584–636, 1892.) W. E. T.

510. *Velocity of Reaction before Complete Equilibrium and before the Point of Transition. Part III.* **M. Wilderman.** (Phil. Mag. 4. pp. 468–489, Oct., 1902.)—This forms a continuation of the author's theoretical discussion of the velocity of change in heterogeneous systems [see Abstract No. 871 (1903)]. In the first part of the paper the author is at great pains to prove that above and below a point of complete equilibrium (point of transition) only one of the two opposite reactions is taking place, and that therefore at such a point the equilibrium is of a *static* not of a *dynamic* nature. [It admits, however, of simple thermodynamical proof that, for example, although the solvent need not necessarily freeze out from a supercooled liquid, the solid solvent cannot melt therein. There is, therefore, no question whatever of the possibility of two opposite and simultaneous reactions, and no need for such a discussion.] In a subsequent portion of the paper the author maintains at great length that chemical action between substances is restricted only to homogeneous substances. [This idea has been, however, already introduced and discussed by Nernst and Ostwald.

It is difficult to detect in this paper anything which has not been previously discussed either by the author himself or by others.] F. G. D.

511. *Phase Diagram of Phenol.* **G. Tammann.** (Ann. d. Physik, 9. 2. pp. 249–270, Sept., 1902.)—The author has discovered a second crystalline phase of phenol. It is denser than the ordinary one, and only exists in stable equilibrium at high pressures. Measurements and diagrams are given showing the equilibrium curves, Phenol I.—Melt, Phenol II.—Melt, and Phenol I.—Phenol II. The triple point of Melt—Phenol I.—Phenol II. occurs at a temperature of about 62·5° C. and a pressure of about 2,100 kg. per sq. cm. The volume and energy changes accompanying the melting of the two crystalline phases and their mutual transition are considered in detail and the effect of impurities on a triple point of the above sort is discussed mathematically. Very peculiar phenomena occur at temperatures below 30° C. Whereas at higher temperatures, on varying the volume of a system containing Phenol I. and Phenol II., the pressure attains the same equilibrium value, whether this is reached by a rising or by a falling pressure, at temperatures below 30° C. there is a noticeable difference in the two cases. To explain this the author has recourse to Duhem's theory of pseudo-equilibria,

and assumes that with falling temperature the equilibrium curve Phenol I.—Phenol II. bifurcates, producing a region of pseudo-equilibrium (between the two limiting branches of the curve) in which both crystalline phases can coexist. Reference is made to similar phenomena in the case of ice and of iodide of silver, and the author discusses the various possibilities which may occur in such cases of pseudo-equilibria between solid (crystalline and amorphous) phases. The phenomena exhibited by the crystalline varieties of calcium carbonate and carbon are discussed from this point of view. In conclusion the author suggests that earthquakes are caused by the spontaneous occurrence of retarded transformations of different crystalline varieties.

F. G. D.

512. *Space Conception of Distribution of Phases in Binary Mixtures.* **H. W. Bakhuis Roozeboom.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 276–280, Sept. 27, 1902.)—The author has, in the course of his researches, availed himself very frequently of graphic representations illustrating the boundary of the existence of either simple phases or phase complexes. In this paper it is suggested to represent by a 3-dimensional figure the case of a binary system, it being presumed that only the two components of the system are present as solid phases. For the case of either chemical compounds or mixture crystals occurring as additional solid phases, other figures are devised, which, however, may easily be derived from the figures described and recorded in this paper. In this figure the temperatures are represented by the lengths, the concentration of the mixtures possible in the gaseous and liquid states by the breadths, whereas the heights serve to represent the pressure. Provided this figure (a very full discussion of which is given) bei nvestigated in its whole for any system of two substances, it would afford a means of reading, for every mixture, every temperature, and every pressure, the phases it is made up of, and as to liquid and vapour, the composition of each of them as well. For systems of *two* phases, the relative quantities are equally to be derived from the figure, whereas in the case of *three* or *four* phases the ratios of volumes have in addition to be given. The figure enables also the states assumed by a mixture to be determined, as the temperature, pressure, and concentration are varied. A. G.

513. *Equilibria of Phases in the System Acetaldehyde + Paraldehyde.* **H. W. Bakhuis Roozeboom.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 280–284, Sept. 27, 1902.)—The character of equilibria of phases is exclusively governed by the number of elements independently variable; the system is made up of its components. This number is eithere qual to or smaller than the number of kinds of molecules, as there may occur molecules capable of passing into one another by association, ionisation, or isomerisation. If these molecular transformations take place at a rate faster than the equilibria of phases, they will not influence the latter. Thus, the freezing-point of water, though a mixture of at least two kinds of molecules, is as well defined as the one of an elementary body. If, however, the rate of molecular transformation be slow, the system, on being treated rapidly, will behave like a system of more components, as compared with the case of a slow treatment. The influence of this fact on the freezing phenomena has been tested by Hollmann, in the author's laboratory, on the system acetaldehyde + paraldehyde. In this system no molecular transformation is observed without a catalyser, the behaviour being as in the case of two components, whereas with a trace of sulphuric acid it undergoes trans-

formations as rapid as to behave like a system of one component. The following results are recorded by the author: The melting-point of paraldehyde is lowered from 12°·55 to −119°·9, by adding increasing amounts of acetaldehyde, whereas the melting-curve of the latter does not go any farther than from −118°·45 to −119°·9. The boiling-points are found to rise from 20° F., as corresponding to pure acetaldehyde, to 123° F., the value corresponding to paraldehyde. In the third place, the critical temperatures of the components of some mixtures were determined. If, however, a trace of a catalyser, especially an acid, be added, the two kinds of molecules are capable of being converted into one another, until the equilibrium corresponding to the values of p and t is reached. Now, it is shown that this addition will cause the boiling-point of *all* the mixtures to assume very rapidly a value 41°·7. The displacements of the equilibria are fully discussed, many conclusions being derived as to other well-known phenomena. A representation of this behaviour by means of a three-dimensional figure is suggested [see preceding Abstract], the special equilibria possible in the case of molecular transformations turning out to be represented by cutting the general figure by the equilibrium-plane of the molecular equilibria in each phase. A. G.

514. *Chemical Dynamics and Statics under the Action of Light.* **M. Wilderman.** (Roy. Soc., Phil. Trans. 199. pp. 337–397, Oct. 17, 1902. Roy. Soc., Proc. 70. pp. 66–74, May 31, 1902) (Abstract.)—With the object of investigating the laws governing the velocity of chemical reaction and chemical equilibrium, when caused by the introduction of light into the system, the author undertook experiments leading to direct quantitative measurements. The reaction studied was $CO + Cl_2 = COCl_2$, and great precautions were taken to prepare the gases pure, because of the important effects of traces of air and damp. The light used was acetylene, with special arrangements for keeping it constant in intensity and composition. It was found that the velocity of formation of $COCl_2$ in light at any time was directly proportional to the product of the reacting masses at the time, as it ought to be according to the laws of action of mass, if the same chemical reaction would go on in the dark as the outcome of chemical affinity. Also giving instances of chemical equilibria in homogeneous systems in light, in which one of the opposite reactions goes on only in light, and the other in light and dark, the author shows that chemical equilibrium in homogeneous systems must also and can only follow the laws of action of mass, as they follow in the dark. The phenomena of chemical induction and deduction (occurring when the system is exposed to and removed from light) are dealt with, as well as the induction and deduction periods of energy. W. E. T.

515. *Decomposition of Urea.* **C. E. Fawsitt.** (Zeitschr. Phys. Chem. 41. pp. 601–629, Sept. 5, 1902.)—Experiments on the velocity of decomposition, at 100°, of urea dissolved in water, acid and alkali solutions show that urea is converted directly into ammonium carbonate only by very concentrated alkali solutions, whilst in more dilute alkali solutions, water, or acids, it is first transformed into ammonium cyanate, with which it exists in a state of equilibrium; complete decomposition of the urea can only occur if the ammonium cyanate is converted into carbonate. The transformation of urea into the cyanate is a reaction of the first order, and its velocity increases very rapidly as the temperature rises, the temperature coefficient of the reaction between 90° and 99° being 8·6. From the velocity of the change of urea into ammonium cyanate determined from conductivity measurements of the solutions, together with Walker and Hambly's values for the velocity of formation of urea (J. Chem. Soc., 1895, 67. p. 746), the equilibrium constants can be calculated, and the numbers thus arrived at agree well with those given by Walker and Hambly's direct measurements; the equilibrium appears to be altered by rise of temperature, more of the cyanate being formed. The equilibrium between urea, hydrochloric acid and urea hydrochloride is, however, scarcely affected by change of temperature. The conversion of urea into ammonium carbonate *viâ* the cyanate is not appreciably reversible. T. H. P.

516. *Decomposition of Ammonium Nitrite.* **A. A. Blanchard.** (Zeitschr. Phys. Chem. 41. pp. 681–708, Sept. 26, 1902.)—The experiments here described were made with a view of determining the influence on the rate of decomposition of ammonium nitrite, of the presence of other substances and ions. It is found that this decomposition only attains a measurable velocity when hydrogen ions and free nitrous acid are present in the solution. Owing to the decomposition of the free nitrous acid, a smaller or greater evolution of nitric oxide always takes place, but the main reaction is quite independent of this secondary action. The velocity of decomposition is proportional to the concentrations of the NH_4 and NO_2 ions and is only increased by hydrogen ions and free nitrous acid; from this it is concluded that two independent changes proceed simultaneously, each of them resulting in the evolution of nitrogen. The affinity constant of nitrous acid, calculated from the accelerating action of the acid on the decomposition of ammonium nitrite, has the value $k = 0{\cdot}00040$. This number, which agrees with that (0·00045) obtained by Schumann in another way, is probably from 10 to 20 per cent. too low, owing to the inexactitude of the method for measuring the concentration of the NO_2 ions in solution. The investigations described have led also to: (1) A qualitative method of detecting nitrous oxide in presence of nitrogen and nitric oxide; (2) Two modifications of the method of determining velocities of reaction by measuring the gas evolved, and (3) The observation that ammonium salts reduce permanganate to a small extent if nitrous acid is also present. T. H. P.

517. *Dissociation of Mercuric Haloid Salts.* **H. Morse.** (Zeitschr. Phys. Chem. 41. pp. 709–734, Sept. 26, 1902.)—Results are given of measurements (1) of the solubility of silver chloride in mercuric nitrate solutions of various concentrations, and (2) of the distribution of mercuric chloride between water and toluene and between mercuric nitrate solutions and toluene. The numbers obtained indicate the existence in these solutions of the kathion $HgCl^{\cdot}$, confirmation of which is given by the results of electrolytic transport experiments. From the values yielded by the solubility and distribution experiments, the following equilibrium constants for a temperature of 25° have been calculated: $(Hg^{\cdot\cdot} \times Cl')/Hg^{\cdot}Cl = 0{\cdot}85 \times 10^{-7}$; $(Hg^{\cdot}Cl \times Cl')/HgCl_2 = 2{\cdot}8 \times 10^{-7}$; $(Hg^{\cdot\cdot} \times Cl'^2)/HgCl_2 = 1{\cdot}0 \times 10^{-14}$; $(Hg^{\cdot\cdot} \times HgCl_2)/(Hg^{\cdot}Cl)^2 = 0{\cdot}13$; $(Hg^{\cdot\cdot} \times Br')/Hg^{\cdot}Br = 0{\cdot}4 \times 10^{-9}$; $(Hg^{\cdot\cdot} \times I')/Hg^{\cdot}I = 0{\cdot}4 \times 10^{-13}$; in the cases of the other bromine and iodine compounds, the equilibrium is disturbed by the formation of complex molecules in solution. Two such complex substances having the compositions $HgBr_2$, $Hg(NO_3)_2$ and $2AgBr$, $Hg(NO_3)_2$, have been isolated; the ions formed by these two compounds in solution are probably: (1) $HgBr^{\cdot}$ and NO_3', and (2) $Ag_2Br^{\cdot}$, $HgBr^{\cdot}$ and NO_3'. The mass law is found to hold over the range covered by the author's experiments. The solubility of mercuric chloride in water at 25°, which was determined for the above investigations, is 71·17 grams per litre or 0·262 gram.-mol. per litre. T. H. P.

518. *Reaction between Potassium Persulphate, Hydrogen Iodide and Phosphorous Acid.* **W. Federlin.** (Zeitschr. Phys. Chem. 41. pp. 565–600, Sept. 5, 1902.)—In a solution containing potassium persulphate, hydrogen iodide and phosphorous acid, two distinct reactions take place, namely, (1) oxidation of the iodine ions to iodine by the persulphate, and (2) reduction of the iodine to the ionic condition by means of the phosphorous acid. The iodine ions thus play the part of a catalytic agent. The investigations described by the author were made with the view of determining whether the total velocity of the reaction corresponds with that given by the separate velocities of the above two reactions. The first of these, that between the iodine ions and the persulphate, is found to be of the second order, as has already been shown by Price; the interaction of the iodine and phosphorous acid is also of the second order. A slight action takes place between the persulphate and the phosphorous acid, but the velocity is too small to exert any influence on the total action. From the results obtained for the component actions, equations are deduced giving the concentrations of the iodine and persulphate in the reaction, but the numbers thus arrived at are not in good accord with those experimentally found; if the phosphorous acid present is reduced in quantity, a better agreement is obtained, so that the disturbing effect is probably the influence of this acid on the velocity of the reaction between the iodine ions and the persulphate. The velocity of the total reaction is considerably increased when iron or copper salts are present, but such addition is without influence on the iodine-phosphorous acid reaction. Curves are given showing the effect on the reaction of change of concentration of the reacting substances and of change of temperature, and these agree well with the values calculated from the author's formulæ. T. H. P.

519. *Aqueous Ammonia Solutions.* **C. Frenzel.** (Zeitschr. Anorg. Chem. 32. 3. pp. 319–341, Oct. 18, 1902.)—The author endeavours to deduce the nature of aqueous ammonia solutions from known phenomena and a series of simple experiments. By studying the relation of ammonia to the substituted amines, it is shown that ammonia in solution is very likely to undergo molecular decomposition to a high degree. On the other hand, a combination of ammonia and water occurring to any considerable extent is not to be expected on account of the very small tendency of trivalent nitrogen to pass into the pentavalent modification. This passage is rendered still more difficult, as hydroxyl having little tendency to pass into the ionic state, the incorporation of water with ammonia with formation of an electrolyte can occur only slowly and to a small degree. Additional evidence is derived from thermo-chemical data. The perfect analogy, moreover, of ammonium salts with the corresponding alkali salts of strong acids would seem to militate against the hypothesis of a complete or considerable combination. Ammonia possesses, no doubt, a conductivity approaching very closely that of pure water in order of magnitude, which is due to dissociation with formation of $H^{\cdot}$- and NH_2'-ions. The author has succeeded in establishing the presence of these ions by drawing the dissociation curves. It is next shown that the strength of ammonium hydroxide can be adequately estimated only in the case of the acidity of NH_3 being practically neutralised, so as to avoid a dis-

turbance of the experiments by the presence of NH_3, viz., in the case of its salts with strong acids. As ammonium hydroxide in these salts behaves like an alkali, it is inferred that liquid ammonia solutions will for the most part contain free NH_3 and traces of NH_4OH, which may be considered as being completely dissociated into its ions. After pointing out the analogy with the diazo-compounds, which is strongly in favour of his hypothesis, the author finally adduces some data as to the electrolysis of ammonia, which appear to confirm the views expressed. A. G.

520. *Ionic Velocities in Liquid Ammonia Solutions.* **E. C. Franklin** and **H. P. Cady.** (Electrochem. Ind., Philadelphia, 1. p. 8, Sept., 1902. Abstract of a paper read at the Pittsburg meeting of the A.A.A.S., July, 1902.) —The following figures for solutions of potassium nitrate show that the conductivity of a salt dissolved in liquid ammonia may reach a value much greater than when dissolved in water, although the maximum value is reached only at much greater dilutions than in aqueous solutions :—

Dilution.	Molecular Conductivity of KNO_3 in NH_3 at −33°.	H_2O at 18°.
1	—	75·2
10	88·0	108·7
100	138·5	114·0
1,000	245·0	119·0
10,000	319·0	122·0
50,000	337·0	121·5
70,000	338·0	—

This must mean that the coefficients of ionisation are smaller, but that the ionic mobilities are very much greater in ammonia than in water. The latter conclusion has been verified by direct measurements of ionic velocities, the method used being that which depends on noting the rate of motion of the boundary between two solutions. The following figures are given :—

	Velocity in cm. per sec. per volt in NH_3 at −33°.	H_2O at 18°.
NH_4	0·00133	0·00055
K	0·00167	0·00057
Na	0·00132	0·00035
Ag	0·00103	0·00046
NO_3	0·00166	0·00053
Br	0·00168	0·00059

These values are in very fair agreement with the conductivity measurements of Franklin and Kraus. T. M. L.

521. *Cadmium Amalgams and their Electromotive Behaviour.* **H. C. Bijl.** (Zeitschr. Phys. Chem. 41. pp. 641–671, Sept. 26, 1902.)—The author's investigations lead to the following results : Cadmium and mercury are miscible, in the fluid state, in all proportions. These mixtures begin to crystallise at temperatures, varying with the proportion of cadmium present, from −38·8° to 320·8°. The mixtures do not belong to one series, but to two, those of the first, which contain from 0 to 65 atomic per cent. of cadmium, beginning to deposit solid at temperatures between −38·8° and 188°, whilst those of the second, with 65 to 100 atomic per cent. of cadmium, commence crystallising at 188° to 320·8°. All the cadmium amalgams solidify gradually over a certain interval of temperature. From the liquid amalgams of the first series, mixed crystals of the mercury type containing from 0 to 75 atomic per cent. of cadmium separate out, while those of the second series deposit mixed crystals of the cadmium type with from 77 to 100 atomic per cent. of this metal; there is hence a gap in the mixed crystal series from 75 to 77 atomic per cent. of cadmium. The lower the temperature the wider this gap becomes, and at 25° it extends from 65 to 80 atomic per cent. of cadmium, so that an amalgam containing a percentage of cadmium between these two limits will separate into two phases at 25°. At low temperatures these limits can only be determined by measuring the e.m.f. of an element with cadmium-amalgam as kathode, cadmium sulphate as electrolyte, and a reversible mercury pole as anode. Where the amalgam contains only a small proportion of cadmium and remains liquid, the e.m.f. of such cells increases regularly with the proportion of cadmium in the amalgam, but for all those concentrations where the amalgam separates into a solid and a liquid phase, the e.m.f. has a constant value. On arriving at the solid amalgams of the mercury type, the e.m.f. again rises with the cadmium-content; then come amalgams within the miscible limits, and here again the e.m.f. remains constant; finally, for the amalgams of the cadmium type, the e.m.f. increases regularly to that of pure cadmium. The irregularities observed by Jaeger and Cohen in the earlier forms of Weston cells are explained by the fact that they contained an amalgam with 22·9 atomic per cent. of cadmium, and this, when cooled below 20°, solidifies completely to mixed crystals; hence the true equilibrium was only slowly attained.

The author gives the amounts of heat developed on converting one gram-atom of cadmium into the various amalgams, and considers the significance of these numbers with regard to the nature of the amalgams as mono- or poly-phase systems. T. H. P.

522. *Potential-difference between Metals and Completely Dissociated Solutions of their Salts.* **A. Einstein.** (Ann. d. Physik, 8. 4. pp. 798–814, July, 1902.) —In this paper the author developes from thermodynamic principles formulæ for the dependence of the electric potential difference of a completely dissociated salt-solution and an electrode consisting of the metal of the solution on the concentration of the solution and the hydrostatic pressure. He shows that in a given solvent it is independent of the nature of the electro-negative constituent, and investigates its dependence on the nature of the solvent. Thence he derives and explains a method for the experimental determination of molecular forces. W. E. T.

523. *Theory of Concentration Cells.* **H. S. Carhart.** (Electrochem. Ind., Philadelphia, 1. p. 9, Sept., 1902. Abstract of a paper read at the Pittsburg meeting of the A.A.A.S., July, 1902.)—A concentration cell in which the e.m.f. within the cell is from the concentrated to the dilute solution has been constructed by using nickel electrodes immersed in a solution of nickel sulphate or chloride. T. M. L.

524. *Influence of Temperature on the Conductivity of Electrolytic Solutions.* **W. R. Bousfield** and **T. M. Lowry.** (Roy. Soc., Proc. 71. pp. 42–54, Oct., 1902.)—This paper contains: A summary of the evidence for the existence of upper and lower limits of conductivity of a liquid electrolyte, apart from its boiling- and freezing-points; a discussion of the probable position of these limits on the scale of temperature in the case of certain aqueous and other electrolytes; and a review of the influence of temperature

on conductivity over the whole range of temperature within which electrolysis can take place.

The factors determining the form of conductivity-temperature curves are : (1) The increase of viscosity and decrease of the mobility of the ions as the temperature falls, and (2) the decrease of the coefficient of ionisation with rise of temperature ; the temperature coefficient of conductivity will therefore be either + or — according as one or other of these influences predominates. In a recent paper, Kohlrausch has deduced the values of the temperature coefficient of conductivity in aqueous solutions of infinite dilution, and has found that the conductivity-temperature curves of all such solutions would, if produced, cut the temperature axis at points lying within a degree or two of $-38{\cdot}5^\circ$ C., a temperature which may be termed the "conductivity zero of the solvent" [see Abstract No. 524 (1902)]. Kohlrausch also states that the viscosity of water may be represented by a formula which leads to an infinite value at $-38{\cdot}5^\circ$ C. The authors, however, regard the existence of such a sharply defined critical temperature as improbable, and consider it more likely that in an over-cooled solution the relation between conductivity and temperature, as determined from observations above the freezing-point, would cease to hold good near the conductivity zero and that the electrolyte might retain an appreciable conductivity at far lower temperatures. These views are supported by a study of the conductivity of glass, which may be regarded as an over-cooled electrolyte. Kohlrausch and Déguisne gave the conductivity-temperature formula as : $K_t = K_{18}[1 + \alpha(t-18) + \beta(t-18)^2]$, and the authors show that data obtained by Thorpe and Rodger lead to an analogous formula for the viscosity of water, namely—

$$\eta_{18} = \eta_t[1 + \alpha(t-18) + \beta(t-18)^2] ;$$

the values of α and β in the latter expression are very nearly identical with those for the conductivity formula applied to water. The indications of the existence of an upper conductivity zero—due to the decrease of the coefficient of ionisation with rise of temperature—are, in the case of aqueous solutions, but slight, the temperature coefficient of conductivity being positive at ordinary temperatures and remaining so up to the boiling-point in all but a very few instances. For non-aqueous solutions there is a certain amount of evidence, quoted by the authors, of the existence of such an upper conductivity zero. In the case of salt solutions this appears to be higher than for acids, owing to the former being capable of self-ionisation. The above considerations indicate that the general conductivity temperature curve for a composite electrolyte exhibits a maximum with a point of inflexion on either side of it. The authors' results show that such inflexion does exist at a temperature of about 40° C. for lithium, sodium, and potassium hydroxides, and at about 25° C. for calcium, strontium, and barium hydroxides. T. H. P.

525. *Solubility, Electrolytic Conductivity, and Chemical Action in Liquid Hydrocyanic Acid.* **L. Kahlenberg** and **H. Schlundt.** (Journ. Phys. Chem. 6. pp. 447–462, Oct., 1902.)—The potassium salts KI, KNO_3 ,KCNS, $KMnO_4$, K_2CrO_4, and KCNO are very good electrolytes when dissolved in liquid HCN at 0° ; the molecular conductivity of KI and KNO_3 is over $3{\cdot}5$ times as great in HCN as in water, whilst the remaining salts are better conductors in HCN at 0° than in water at 25°. The conductivity of NH_4Cl and of Ag_2SO_4 in HCN at 0° is greater than in water at 18°. But, on the other hand, the acids are incomparably poorer electrolytes in this solvent

than in aqueous solution and silver nitrate conducts only one-fourth as well as in water at 0°; ferric chloride is a slightly poorer conductor in HCN, and $SbCl_3$ and $BiCl_3$ which are decomposed by water are not good electrolytes when dissolved in HCN. The amines examined undoubtedly exist in solution as cyanides. From these results the conclusion is drawn that the relationship between the dielectric constant and the ionising power of the solvent postulated by the Nernst-Thomson rule cannot be confirmed, for the merits of the solvent are clearly dependent on the solute for which it is used. Solutions of KNO_3, NH_4Cl, and KI are better conductors in liquid HCN than in liquid NH_3, but $AgNO_3$ is a poorer conductor. Solutions of KI and KCNS in liquid HCN are much better electrolytes than the corresponding solutions in liquid SO_2. In some cases, such as KI, KNO_3, and $AgNO_3$ the molecular conductivity increases but slightly with dilution, as in the corresponding aqueous solutions, but in other cases, such as KCNS, $KMnO_4$, and K_2CrO_4 the increase is very considerable and far greater than in the aqueous solutions. Comparing the results of these conductivity measurements with those in water, liquid ammonia, and liquid sulphur dioxide, the conclusion is drawn that the conductivity of a solution is not determined by the dielectric constant of the solvent, its state of polymerisation, or its spare valencies, but rather by the specific nature of the compound formed when solute and solvent act on each other to form the solution.

Metallic sodium and potassium liberate hydrogen from dry liquid HCN, but magnesium and sodium carbonate are not acted on by it. A solution of SO_3 in HCN, though it conducted well (sp. cond. 0·0066) did not act on dry magnesium, zinc, calcium carbonate, or potassium carbonate; hydrogen chloride, on the other hand, attacks both magnesium and zinc, but not aluminium, iron, lead, copper, silver, platinum, sodium carbonate, calcium carbonate, or barium carbonate. T. M. L.

526. *Electrolysis of Alkali Chlorides with Platinised Electrodes.* **F. Foerster** and **E. Müller.** (Zeitschr. Elektrochem. 8. pp. 515–538; Discussion, pp. 539–540, July 31, 1902. Paper read before the German Electrochemical Society at Würzburg, May 9, 1902.)—In this paper the authors give the results of experiments directed chiefly to the elucidation of the effect of platinising the anode on the electrolysis of solutions of alkali chlorides, both with and without the addition of chromate. With a platinised anode, the e.m.f. is about 0·5 volt less than with a smooth electrode; but the results obtained by the authors differ in so far from those obtained by Lorenz and Wehrlin [see Abstract No. 1585 (1900)], that chlorate is also produced when a platinised anode is employed. In this case, however, the evolution of oxygen and the formation of chlorate do not begin until later, when the concentration of the hypochlorite has become greater than when a non-platinised anode is used. For the same current, the yield of chlorate is the same whether the anode is platinised or smooth. Since the difference in the behaviour of platinised anodes might be due to the catalytic decomposition of the hypochlorite into hydrochloric and chloric acids and oxygen by the deposit of platinum, special experiments were made to test this; with the result that the velocity with which this catalytic decomposition occurs is too small to account for the production of chlorate and oxygen. Experiments were also carried out with platinised kathodes in conjunction with platinised and smooth anodes. With these platinised kathodes the potential difference is constant when chromate is added, because hydrogen is then evolved at the kathode, which therefore behaves as a hydrogen electrode. When the anode

is platinised the e.m.f., while the current is passing, is lower by about 0·75–0·92 volt than when a smooth electrode is employed, the difference increasing with the duration of the electrolysis. In the case also of solutions of sulphuric acid, sodium hydroxide, and of alkaline solutions of potassium iodide, a higher e.m.f. was required for the electrolysis when a smooth anode was employed, than when a platinised one was used. As the author's experiments show, this difference of e.m.f. with platinised and smooth anode cannot be explained by differences of concentration at the anode, and it is also shown that these differences appear only when there is evolution of oxygen at the electrode. As an explanation of these differences the authors put forward the view that when the anode is smooth, oxygen is occluded in greater amount than when the anode is platinised. The authors discuss briefly the theory of the electrolysis of neutral solutions of sodium chloride with smooth and platinised anode. In the discussion it was pointed out by **Haber** that the differences in the behaviour of the smooth and platinised anodes could be perhaps accounted for by adsorption phenomena between the electrode and the substances discharged at it. A. F.

527. *Vanadium Silicides.* **H. Moissan** and **Holt.** (Annal. Chim. Phys. 27. pp. 277–288, Oct., 1902.)—By heating vanadium tri- or pent-oxide with excess of silicon in the electric furnace, a crystallised vanadium silicide of the composition VSi_2 is obtained. If, however, an excess of vanadium tri- or pent-oxide or carbide is employed, a silicide of the formula V_2Si is obtained. Indications are also present of the formation of another compound, probably VSi, which is, however, readily decomposable and could not be isolated. The authors' experiments show that the laws governing equilibrium in solutions at ordinary temperatures also apply for the reactions taking place in the electric furnace between silicon, copper silicide, and vanadium carbide. T. H. P.

528. *Cobalt Silicides.* **P. Lebeau.** (Annal. Chim. Phys. 27. pp. 271–277, Oct., 1902.)—By heating a mixture of copper silicide and cobalt in a carbon crucible in the electric furnace, a cobalt silicide of the composition CoSi is obtained, whilst if a certain proportion of crystallised silicon is also present, a compound of the formula $CoSi_2$ is formed. These two substances are crystalline and very stable towards the action of acids or oxidising agents, and strongly resemble the corresponding iron silicides. Their chief properties are given. T. H. P.

529. *Preparation of Artificial Diamonds from Silicate Fusions.* **R. v. Hasslinger.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2b. pp. 619–624, 1902.)—By dissolving finely powdered graphite in a fused mixture of silica, aluminium, potassium, sodium, and ferric oxides, magnesium and lime, and allowing the fused mass to cool, the author obtains transparent diamonds having an average diameter of 0·05 mm. [see also Abstract No. 372 (1903).] T. H. P.

REFERENCE.

530. *Law of Atomic Weights.* **G. Johnstone Stoney.** (Phil. Mag. 4. pp. 504–505, Oct., 1902.)—This is supplementary to a former letter [see Abstract No. 493 (1903)], and amends the author's diagram as regards the new atmospheric elements. S. R.